Forest resources assessment 1990

Global synthesis

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Foreword

Governments, the general public and the international community at large have manifested increasing concern over the clearing and degradation of forests in many regions of the world. By devoting a significant part of its debate and decisions to issues of forest conservation and development, the United Nations Conference on Environment and Development (UNCED, Rio de Janeiro, June 1992) has amply reflected this unprecedented concern for the fate of the world's forests.

There cannot be sound decisions and actions, however, in the management of forests at any level, whether local or global, without reliable information on their condition and evolution over time. Such information is indispensable whatever the objective of management of forests, be it production of fuelwood or industrial wood for domestic use or export, conservation of biodiversity, mitigation of climate change at global level or multiple use. Thus, in Chapter 11 of UNCED Agenda 21 titled "Combating deforestation", the assessment and systematic observations of forest resources is made a key element in one of the four programme areas.

In pursuance of its mandate, FAO has undertaken periodic assessments of the world's forest resources, of which the first was nearly 50 years ago in 1946 and the last in 1980. The 1990 Global Forest Resources Assessment builds upon the 1980 study. It has four components: (a) the assessment for the tropical countries; (b) the assessment of the forest resources of the industrialized countries carried out jointly by FAO and the Economic Commission for Europe of the United Nations; (c) the assessment for the non-tropical developing countries; and (d) the global synthesis.

Classifications and definitions used in national forest inventories often differ from one another, since they are designed to satisfy specific national or even local needs. To arrive at a common classification, format and reference date, original data provided by countries had to be reorganized. It must be stressed, however, that the standardized country results in this international report are intended only to secure a consistent global picture; they do not replace the original country statistics which will remain a unique source of reference.

The 1990 global assessment has been a key activity under the FAO Regular Programme, carried out with substantial support from donor countries. Its implementation has benefited greatly from ready cooperation of all countries which are reported upon here, as well as the technical contributions made by many scientific institutions and individuals. This report also reflects the dedication of the staff concerned with Forest Resources Assessment 1990.

This assessment is intended to satisfy many of the urgent information needs of policy makers, the scientific community and the general public. It has revealed, however, a need to fill certain gaps in knowledge and to improve national capacities to carry out their own forest resources assessments. FAO intends to give greater attention to these aspects in future and to make the assessment of the world's forest resources a continuous and evolving programme.

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The assessment for developed countries has been carried out in the framework of the programme of work of the Joint FAO/ECE Working Party on Economics and Statistics, a subsidiary body of the FAO European Forestry Commission and the UN-ECE Timber Committee and under the coordination of Mr. A. Korotkov of the FAO/ECE secretariat in Geneva.

The global synthesis has required considerable complementary work in order to compile a sufficiently comprehensive and comparable core of common information. This would not have been possible without the devotion of the team in which extraordinary efforts were made by Dr. K. D. Singh, Mr. A. Marzoli, Mr. A. Del Lungo, Mr. R. Drigo, Mr. M. Lorenzini, Mr. G Mu'Ammar, Mr. M. Grylle and Ms. J. Rechter. FAO Regular Programme contributions consisted of in-kind assistance and consultancies and were coordinated by Mr. K. Janz and Mr. P. So.

The Food and Agriculture Organization is greatly indebted to all those who assisted in the implementation of the global forest resources assessment 1990 by providing information, advice, facilities and funds.

Table of contents

Page

Foreword iii

Acknowledgements iv

Tables and figures vi

Abbreviations vii

Summary ix

Chapter I BACKGROUND **1**

1 Introduction 1

2 Objectives of the Gobal Forest Resources Assessment 1990 1

3 Geographic coverage 3

4 Implementation of the 1990 assessment 4

5 Critique of data base sources 4

Chapter II RESULTS OF THE ASSESSMENT **7**

1 Global synthesis 7

2 Developed countries 13

3 Developing countries 20

Chapter III SPECIAL ISSUES **25**

1 Experience in the developed countries in gathering information on the role of forests in supplying environmental and other non-wood products and services 25

2 Survey of the process of deforestation and forest degradation in the tropics using high resolution satellite data 31

Chapter IV CONCLUSIONS **41**

1 General conclusions 41

2 Specific conclusions for future assessments 41

Bibliography 45

Annex 1 COUNTRY TABLES *1*

Annex 2 METHODOLOGY AND DEFINITIONS *33*

1 Methodology of assessment for the developed countries *33*

2 Methodology of assessment for the developing countries *37*

3 Definitions *41*

Tables and Figures

TABLES IN THE TEXT

1 Main results of global forest resources assessment 1990 *ix*
2 Geographic area and population by region 2
3 Land Area, forest changes and forest per caput by region 7
4 Total population from 1960 to 2020 9
5 Land requirements for agriculture 9
6 Volume and biomass distribution by region at the year 1990 10
7 Roundwood consumption 12
8 Distribution of protected areas (at least 1,000 ha) 12
9 Distribution of higher plants (including ferns, cycads, conifers and broad leaved species) by region and subregion 13
10 Summary of forest resources statistics by region for developed countries 14
11 Main forest statistics of the eastern european and former USSR countries 17
12 Estimates of forest area and rate of deforestation by geographical subregion 21
13 Comparison of 1980 natural forest area estimates by the FAO 1980 assessment as published in *An interim report on the state of forest resources in the developing countries* and the FAO 1990 assessment published in the present report 22
14 State of forest biomass and annual losses due to deforestation 22
15 Estimates of forest cover area and rate of deforestation by main ecological zone 23
16 Pan-tropical area transition matrix for the standard period 1980-1990 36
17 State of forest inventory in developing countries at end 1990 Annex 2– *38*

COUNTRY TABLES — ANNEX 1

1 Socio economic data 1990 2
2 State of forest inventory 1990 7
3 Area of forest and other wooded land 1990 12
4 Annual changes in forest and other wooded land area, 1980-1990 17
5 Natural Forest Area, Volume Biomass 1990 22
6 Summary tables 27

FIGURES IN THE TEXT

1 Population and GNP by economic region 2
2 Geographic subdivision of the global forest assessment 4
3 Forest area and population: Distribution by region 8
4 Volume per caput by region 10
5 Main geo-referenced data used in assessing the risk of loss of biodiversity in the tropics. 15
6 Importance of functions by area of public and private forest in Europe 26
7 Importance of hunting on public and private forest in selected countries 27
8 Importance of functions on public and private forests in Europe in aggregate 28
9 Importance of hunting on public and private forest in United States 28
10 Pan-tropical continuous forest resources survey design 32
11 Example of spatial and statistical outputs - located along Zaire/Zambia border line 33
12 Pan-tropical woody biomass flux diagram 37
13 Forest cover changes by geographic region 38
14 Forest changes by ecological zone 39
15 Forest cover state and change assessment (using existing reliable data) Annex 2– *39*

Abbreviations

AVHRR	Advanced Very High Resolution Radiometer
COFO	Committee on Forestry
FAO	Food and Agriculture Organization of the United Nations
FAO/ECE	Food and Agriculture Organization of the United Nations/ United Nations Economic Commission for Europe
FINNIDA	Finnish International Development Authority
FORIS 1990	Forest Resources Information System 1990
FRA 1990	Forest Resources Assessment 1990 Project
GIS	Geographic Information System(s)
ITTO	International Tropical Timber Organization
IUCN	International Union for the Conservation of Nature (The World Conservation Union)
LANDSAT MSS/TM	LANDSAT Satellite Multi-spectral Scanner/Thematic Mapper
NASA	National Aeronautics and Space Administration (United States of America)
NOAA	National Oceanic and Atmospheric Administration
UN	United Nations
UNCED	United Nations Conference on Environment and Development (Rio de Janeiro, Brazil, June 1992)
WCMC	World Conservation Monitoring Centre

Summary

The Global Forest Resources Assessment 1990 provides comprehensive information on the current state of global forests and recent changes including area, growing stock, management and conservation. Some information related to the environmental functions of forests is also given.

The FAO 1990 survey was implemented by following similar institutional arrangements, as those used in the previous studies. FAO/ECE, Geneva, was responsible for assessment in developed countries whilst FAO, Rome, conducted the assessment in developing countries as well as the global synthesis.

The objectives of the assessment were to: (i) provide reliable and globally consistent information on the state of forest resources at the end of 1990 and on the extent of changes between 1980 and 1990; and (ii) undertake special studies related to environmental functions of forests.

An overview of main results of global forest resources assessment is given in Table 1.

Table 1
Main results of Global Forest Resources Assessment 1990

Regions	Number of countries by region	Forest & other wooded land			Forest				Other wooded land
		Total	Annual change [1]		Total	%	Per cap.	Biomass	
		1 000 ha	*1 000 ha*	*%*	*1 000 ha*	*of land*	*ha*	*million tons*	*1 000 ha*
Europe	28	194 943	190.8	0.13	149 295	27	0.26	11 864	45 648
Former USSR	3	941 530	51.3	0.01	754 958	35	2.15	51 648	186 572
North America	2	749 289	-316.5	-0.11	456 737	25	1.65	44 948	292 552
Developed Asia & Oceania	3	177 803	-4.2	0.00	71 467	9	0.50	4 137	106 336
Developed regions	**36**	**2 063 565**	**-78.6**	**-0.01**	**1 432 457**	**27**	**1.07**	**112 598**	**631 108**
Africa	53	1 136 676	-2 827.8	-0.26	545 084	18	0.85	72 306	591 591
Asia & Pacific	46	660 270	-999.2	-0.60	497 359	19	0.17	75 269	162 911
Latin America & Caribbean	44	1 259 717	-6 047.2	-0.50	967 469	48	2.16	180 307	292 249
Developing regions	**143**	**3 056 663**	**-9 874.1**	**-0.43**	**2 009 912**	**26**	**0.50**	**327 882**	**1 046 751**
ALL REGIONS	**179**	**5 120 227**	**-9 952.7**	**-0.20**	**3 442 369**	**27**	**0.64**	**440 479**	**1 677 859**

[1] Estimates of area change are not available for the main part of the former USSR. Estimates for the former USSR in regional and world totals include only Belarus and Ukraine

The global assessment included 179 countries with a total land area of 12 900 million ha. Forests constituted slightly over 3,400 million ha or 27 percent of the land area. The total growing stock was 384,000 million m^3 and growing stock per ha 114 m^3.

Forests of the developed regions represent about 42 percent of the global forest area and 43 percent of the total growing stock. In most of the developed countries, net annual increment has been higher than fellings for several decades and consequently there has been a rise in growing stock, despite an overall increasing trend in fellings. The area of forest in the developed regions remained more or less unchanged over the decade 1980 to 1990.

Forests of the developing region represent about 58 percent of the total forest area of the world and 57 percent of the total growing stock. For several decades deforestation and forest degradation have been occurring on an accelerated scale. The loss of forest area during 1980-90 amounts to 163 million ha, of which 154 million ha in the tropics.

During 1980-90 global forests were a net source of 0.9 ± 0.4 Petagrams (Pg) (= 900 ± 400 million tons) of carbon to the atmosphere. Tropical forests served as a source of 1.65 ± 0.4 Pg (1650 ± 400 million tons) of carbon and temperate forests as a sink of 0.74 ± 0.1 Pg of carbon.

The significant reduction in biodiversity coupled with the continuing process of deforestation in developing countries remain major concerns, as does the protection of the environment and nature conservation in the developed regions.

Mainly as a result of population growth and shrinking forest area in the developing regions, per caput forest area fell globally from an average of nearly 1.2 ha in 1960 to 0.6 ha in 1990 and it is projected to be less than 0.2 ha by 2020.

If the population of the world grows as projected by the UN during 1990-2020, deforestation and forest degradation trends are expected to continue and even to worsen, unless policies are set and implemented to conserve the world's forest resources. The problems of local wood shortage, land degradation, global warming, and biodiversity loss are expected to be exacerbated.

At the local level there is emergence of forest management practices with participation of local communities in the developing countries, and the valuation of environmental functions of the forest in the developed countries.

The recognition of environmental functions of forests is increasing both in developed and developing countries as evidenced by the adoption of international conventions on change and biological diversity and of a statement of forestry principles at UNCED 1992. There is a rapidly rising demand for reliable forest resources information at global, regional and national levels, in particular, related to environmental function of forests such as biomass and biological diversity. The 1990 assessment indicates a lack of adequate institutional capacity in both the developing and developed countries to cope with this demand. A concerted effort is required at the national as well as international level to build the needed capacity, as recommended in chapter 11 of UNCED Agenda 21, in order to understand and solve the pressing problems of the world's forests.

CHAPTER I

Background

1

INTRODUCTION

Since the first United Nations Conference on Human Environment in Stockholm (1972), forests in general and tropical forests in particular, have been receiving increased attention from the world community. A high point in international interest was reached at the United Nations Conference on Environment and Development (UNCED) at Rio de Janeiro (1992), which devoted a full chapter, entitled "Combating Deforestation", of its Agenda 21 to the issues of forest conservation and development and adopted the "non-legally binding, authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests".

The valuation of the functions of forests has changed at a very quick pace. The introductory paragraph of the World Forest Inventory in 1963 read as follows: "In the present decade, with world attention focussed on development, there is a need for concerted efforts to provide a complete picture of the resources available for a steadily growing population. A worldwide effort to step up the utilization level of the rich tropical forest resources seems imperative to avoid a world with the vast majority of its population living in conditions of increasing wood shortage. The 1963 World Forest Inventory takes its place as part of this endeavour".

Today environmental functions of forests are high on the agenda. There is even a holistic perception of world forests as part of the *"global ecosystem"*. Models are being built to study global forests as a source or a sink of carbon in the atmosphere, depending on whether there is an increase or decrease in global forest biomass. Several questions have been posed by policy-makers, the scientific community and the public at large. What is the area and mass of the remaining world forests? At what rate and in what way are they changing? What are the causes of change? What are the ecological, economic and social impacts? And so on.

It is against this background of global concern that the present publication should be considered. Efforts have been made to reflect some of the important global concerns, related to forest resources issues of the early twenty-first century. However, much remains to be achieved in this respect.

2

OBJECTIVES OF THE GLOBAL FOREST RESOURCES ASSESSMENT 1990

The ***long-term goals*** of the FAO Global Forest Resources Assessment are the following:

i) assist member countries and the world community in reviewing policies, promoting multilateral cooperation and taking appropriate action for the conservation, development and management of global forest resources;
ii) support studies of a regional and international nature requiring country forest resource information in a common and harmonized format;

The ***immediate objectives*** of the Global Forest Assessment 1990 were to:

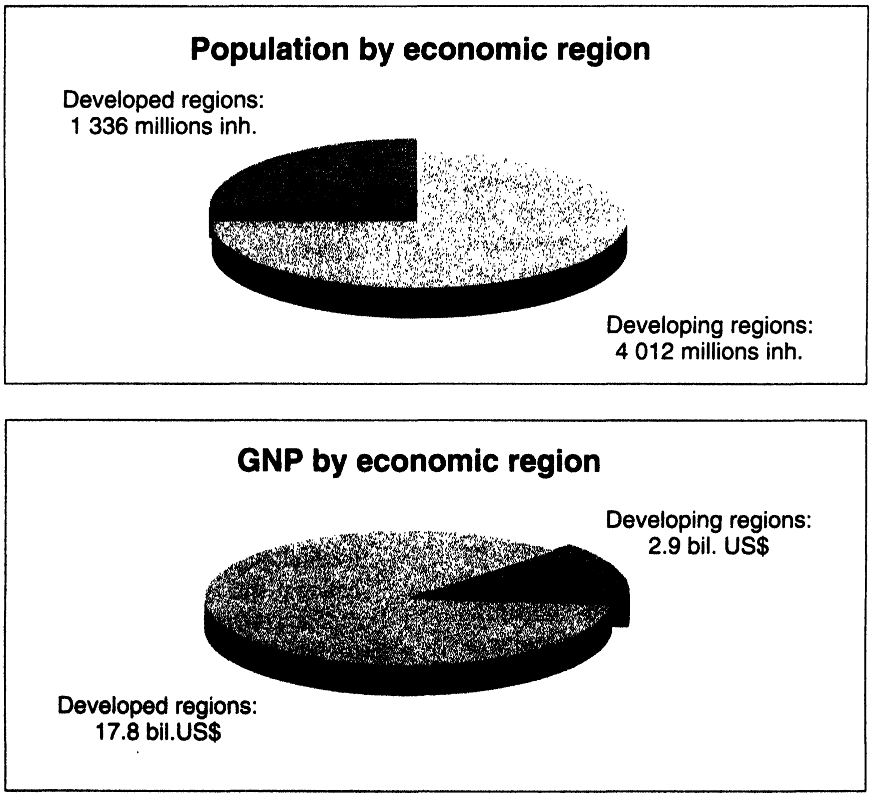
i) carry out an assessment of forest resources on a global basis for the reference year 1990, and estimate the changes that have taken place during the decade 1980-1990;
ii) study the environmental and non-wood goods and services provided by forests in the temperate zones;
iii) study the environmental implications of deforestation and forest degradation and the process of change in the tropics; and
iv) disseminate the database and the methodologies of assessment to the concerned national and international institutions.

Immediate objective (i) concerns the generation of a **data base**; objectives (ii) and (iii) involve the building of **knowledge base** on the environmental and other beneficial functions of forests; and objective (iv) concerns the building of national and international **institutional bases** for both the present and future forest resources assessments.

Table 2
Geographic area and population by region

Region	Land area	Population				Gross National Product	
		Total 1990	Density 1990	Annual growth 1980-1990		US$ per caput 1990	Annual growth 1980-1990
	million ha	*million inh*	*inh/km²*	*million inh/year*	*%*		*%*
Europe	550	565	103	3.3	0.6	12 722	2.2
Former USSR	2 139	350	16	3.3	1.0	3 284	2.2
North America	1 835	276	15	2.4	0.9	21 673	3.1
Developed Asia & Oceania	818	144	18	0.9	0.6	24 430	4.2
Developed regions	**5 342**	**1 336**	**25**	**9.9**	**0.8**	**13 362**	**2.8**
Africa	2 964	642	22	15.7	3.0	470	0.0
Asia & Pacific	2 613	2 922	112	50.7	1.9	602	3.3
Latin America & Caribbean	2 016	448	22	8.6	2.2	2 162	-0.1
Developing regions	**7 594**	**4 012**	**53**	**75.0**	**2.1**	**763**	**1.8**
ALL REGIONS	**12 936**	**5 348**	**41**	**84.9**	**1.8**	**4 063**	**1.9**

Figure 1
Population and GNP by economic region



3
GEOGRAPHIC COVERAGE

The assessment covers 179 countries with a total land area of 12 936 million ha. A list of countries appears in the country tables under Annex 1. For the purpose of reporting, following the pattern of the 1991 FAO Production Yearbook, the countries have been grouped into two economic regions, viz. developed and developing; and seven geographic regions, viz. Europe, the former Union of Soviet Socialist Republics (USSR), North America, developed Asia and Oceania, Africa, Asia and the Pacific and Latin America and the Caribbean. Table 2 provides an overview of the geographic area and population of the regions.

The demographic and economic status of the regions (see Figure 1) is an important factor in shaping the state of forest resources, as will be discussed later in this report.

Only a brief description of the methodology is presented here as more detailed information is available in Annex 2 and the following three publications:

i) *The Forest Resources of the Temperate Zones*, The UN-ECE/FAO 1990 Forest Resources Assessment, New York, 1992 (in English, French and Russian). United Nations ECE/TIM/62 (2 vols).
ii) *Forest Resources Assessment 1990: Tropical Countries*, FAO Forestry Paper 112, Rome, 1993 (in English, French and Spanish)
iii) *Forest Resources Assessment 1990: Non-tropical Developing countries*. Misc. paper, FAO Rome

In the developed countries the assessment was implemented by means of a detailed enquiry, covering the most important forestry information. The following additional sources of information have been used by the secretariat to complete the enquiry:

- official data taken from national forest inventories or other equally authoritative sources;
- estimates provided by national correspondents, based on their knowledge and experience or that of other experts;
- secretariat estimates based on recent FAO and ECE forest resources publications, forestry fact sheets, official journals, etc.

For developing countries, the assessment has been carried out in two complementary phases:

- ☐ **Phase I:** compilation of existing reliable survey data of the developing countries, standardization of inventory data according to a common classification system and their adjustment to the common reference years viz. 1980 and 1990.
- ☐ **Phase II:** monitoring of tropical forest cover and its changes using remote sensing techniques.

The systems of classification and data gathering, followed for the developing and developed regions, differ in important ways. The differences are partly due to historical reasons and partly to the type of forest formation, as well as to socio-economic and associated institutional factors. Some distinctive features of the forestry situation in the tropics are: large scale deforestation, shifting cultivation, site and growing stock degradation, lack of management on much of the forest area, presence of large areas of heterogeneous and uneven-aged forests. There is also a relative lack of survey institutions in developing countries as compared to developed countries. These facts called for different approaches to assessment in the two economic regions.

4
IMPLEMENTATION OF THE 1990 ASSESSMENT

The Eighth Session of the Committee on Forestry (COFO) held in Rome, 21-25 April 1986, recommended the "strengthening of FAO's programme of collection, evaluation and dissemination of information related to forest resources and resource development" and the "updating of information on tropical deforestation in order to provide reliable baseline data" (paragraph 45). These recommendations were endorsed by the FAO Council at its Nineteenth Session in Rome, November 1986.

The preparations for the 1990 assessment were undertaken by the FAO Forestry Department in 1987. The FAO/ECE/FINNIDA "Ad Hoc Meeting on World Forest Resources Assessment" was held in Kotka, Finland, in October 1987. Forty experts took part in the meeting: 20 from developing countries, and 20 from developed countries, representing a broad cross-section of expertise. Four major areas for appropriate assessment were identified by the Kotka meeting including the need for:

i) an estimation of the current state of forest cover and its rates of change;

ii) an estimation of world forest volume and biomass;

iii) up-to-date information on forest management techniques, harvesting, forest plantations, etc.; and

iv) a study of the environmental impacts and service functions of forests.

The assessment was organized at national, regional and global levels, as shown in Figure 2. FAO/ECE Geneva was responsible for collecting and compiling the data relating to the developed countries. FAO, Rome, was responsible for coordinating and conducting the assessment in the developing countries, and for preparing a global synthesis of the two assessments.

5

CRITIQUE OF DATA BASE SOURCES

A country-by-country evaluation of source data is given in Table 2 of Annex 1. Only an overview is presented here.

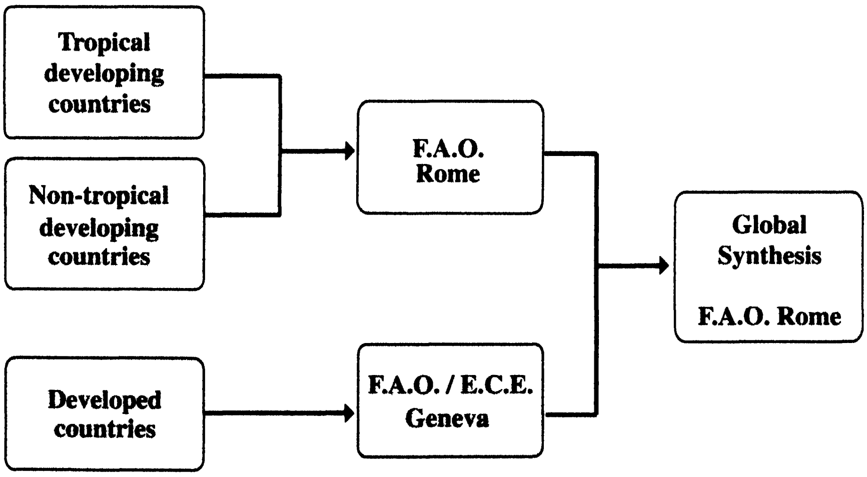
Developed countries: It has been possible to compile detailed data for most countries with accuracy which generally exceeds by far that achieved for developing countries. Data on growing stock, woody biomass, growth rates and harvest yields are included. However, the quality and quantity of the data vary considerably between the countries, and there are many gaps in the information supplied. Therefore, regional totals cannot be made for all variables studied. Moreover, core definitions have been interpreted and applied quite differently in the various country groups due to differences in basic concepts and schools of thought.

Developing countries: The situation can be described as follows:

- Out of 143 countries assessed, all except seven possessed one estimate of forest cover carried out sometime between 1970 and 1990, mostly based on remote sensing.
- The variations in the date of the collection of the country data still present a major constraint. It has been found that on average the country data made available for the 1990 assessment were, in fact, close to ten years old, i.e. relating to around 1980;
- Twenty-five countries had carried out more than one forest cover assessment, which formed the basis for developing the adjustment function.
- There had been substantial developments in technological capability, in particular the

Figure 2

Geographic subdivision of the global forest assessment



application of geographic information systems (GIS), remote sensing and modelling techniques.

Global synthesis: This component was not designed in the planning stage, but was carried out as a final operation after the completion of the assessments for the developed and developing countries.

Results obtained regarding forest area change are incomplete and not conclusive. In estimating area changes, there are two problems. The first concerns the concept of "gross" and "net" change. The positive and negative changes in the forest cover of a country may cancel each other out and produce a net change in forest cover close to zero. Purely for forest area accounting this does not matter; however for the assessment of the "environmental functions" of the forest, it is preferable to have separate estimations for both positive and negative changes in forest cover.

The second question concerns changes in the definitions and mensurational standards used in a country over time. This may result in estimates which include "real change" as well as "spurious change" due to improvements in measurement techniques. In such a case, it is necessary to reappraise the baseline results according to the improved definitions and only then compare values at two different points in time. Only in this way can valid estimates of change be obtained.

On a global scale further complications arise because definitions and/or measurement techniques differ among countries. These may produce estimates at global level of unknown reliability. In the 1990 assessment, harmonization of country data on a global basis was undertaken for the developing countries, but not for the developed ones. This, however, should not distort the results as the magnitude of change in the developed countries is rather small.

In the context of change assessment, the pan-tropical survey based on remote sensing implemented as a part of Forest Resources Assessment 1990 Project, deserves a special mention. It provides statistically reliable and consistent estimates of forest cover over space and time. Of particular interest are the "change matrices" which show the extent as well as direction of land cover changes and can thus help to explain the process of deforestation and forest degradation and, in particular, the transfer of forest land to agriculture and other purposes.

CHAPTER II
Results of the assessment

1
GLOBAL SYNTHESIS

This section presents the results at the global level on the current status of forest cover and its rate of change, growing stock, forest management and conservation. Environmental implications of forest cover change, in relation to land degradation, global climate change and biodiversity loss, are dealt with briefly.

Forest area status

The definition of *forest* used in the present assessment is rather broad and includes lands with a minimum crown cover of 20% in the developed countries and 10% in the developing ones.

The assessment shows that forests (see Table 3) constitute 3 443 million-ha or 27% of the land area. Forest area on a per caput basis amounts to 0.6 ha. The distribution of forest area and population by region is given in Figure 3.

The forest area, as percent of land area, in the developed and developing countries is 27% and 26%, respectively. In terms of per caput, however, the distribution is very uneven: 1.1 ha, in the developed and 0.5 in developing countries.

Forest and other wooded land, (the latter includes other formations of woody vegetation such as open woodland, scrub and brushland, forests under shifting cultivation, etc.), covers 5 120 million ha or one and a half times as much as the total area of forests alone.

Forest area change

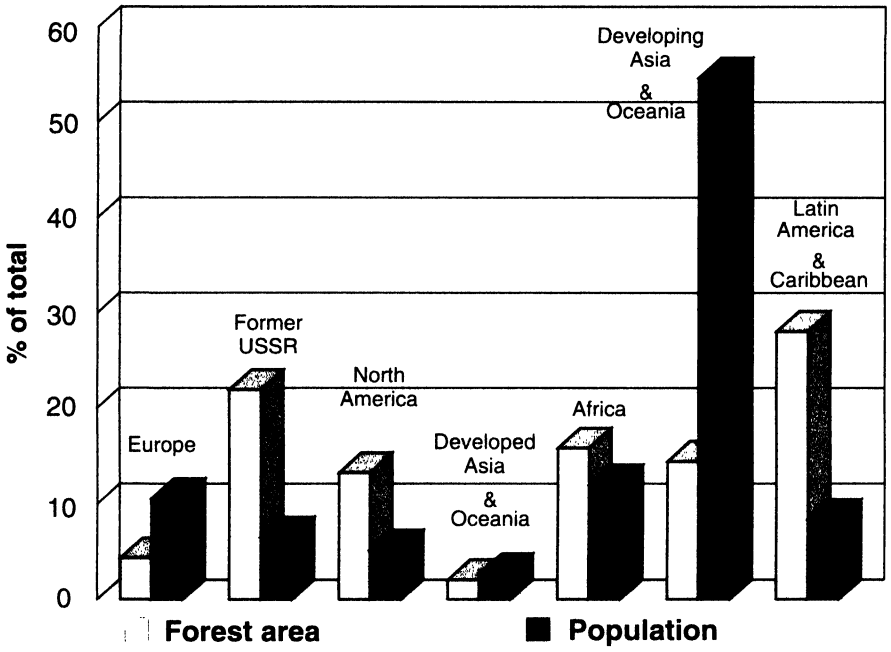
In the developed countries, (excluding former USSR), there is an annual increase, mainly in Europe, by 0.19 million ha of forest and other

Table 3
Land area, forest changes and forest per caput by region

Region	Land area	Forest & Other Wooded Land			Forest		
		Status	Annual Change 1980-90 [1]		Total	% of land	Per Caput
	million ha	*million ha*	*1 000 ha*	*%*	*million ha*	*%*	*ha*
Europe	550	195	191	0.13	149	27	0.3
Former USSR	2 139	942	51	0.01	755	35	2.2
North America	1 835	749	-317	-0.11	457	25	1.7
Developed Asia & Oceania	818	178	-4	0.00	71	9	0.5
Developed regions	**5 342**	**2 064**	**-79**	**-0.01**	**1 432**	**27**	**1.1**
Africa	2 964	1 137	-2 828	-0.26	545	18	0.9
Asia & Pacific	2 613	660	-999	-0.60	497	19	0.2
Latin America & Caribbean	2 016	1 260	-6 047	-0.50	967	48	2.2
Developing regions	**7 594**	**3 057**	**-9 874**	**-0.43**	**2 010**	**26**	**0.5**
ALL REGIONS	**12 936**	**5 120**	**-9 953**	**-0.20**	**3 442**	**27**	**0.6**

[1] Estimates of area change are not available for the main part of the former USSR. Estimates, for the former USSR in regional and world totals include only Belarus and Ukraine

Figure 3
Forest area and population: Distribution by region



wooded land and a decrease, mainly in North America, by 0.32 million ha. For the Developed Regions as whole there is an annual decrease by 0.08 million ha of forest and other wooded land.

In the developing countries (see Annex 1: Table 4) there is an annual increase through forest plantations by 3.2 million ha, and a decrease of forest area by 16.3 million ha through deforestation, of which 15.4 million ha in the tropics. This gives a net decrease of forest area of 13.1 million ha. However, 2.1 million ha of deforested area goes to other wooded lands specially shifting cultivation, thus the net change in the forest and other wooded land class is only 11.0 million ha. Thus, the net decreases, of forest and other wooded lands including developed and developing countries, is estimated annually at 11.1 million ha.

The above shows that a detailed account of area changes is necessary in order to understand fully the environmental implication of forest changes.

Long-term trends

The Forest Resources Assessment 1990 Project conducted a special study of the long-term forest area changes in the tropics during 1960 - 1990 using all available reliable data relating to forest cover at sub-national level (145 multi-date and 499 single date surveys). The loss of forest cover during the period 1960-1990 was estimated approximately at 450 million ha. This equals the total forest area of the North America region estimated in 1990. Future trend, as in the past, is expected to be determined mostly by changes in the developing countries. Demographic changes will, probably, be the most important determining factor in accounting for change, followed by other factors such as economic growth, and government policy.

During 1960-1990 the population in the developing countries roughly doubled in number, from 2 to 4 billion (see Table 4). It is projected by the UN that in 2020 the population will reach a level of 7 billions, viz. an increase of 3 billions in a 30 year period.

To the people and governments of these countries, food and shelter will be their first concerns followed by fuel and fodder. The adverse effects on forests of this unprecedented population growth are not difficult to conceive.

Table 4
Total Population from 1960 to 2020 (estimated)

Economic Regions	Population *(in millions)*		
	1960	1990	2020
Developed	910	1 143	1 238
Developing	2 111	4 141	7 056
TOTAL	**3 021**	**5 284**	**8 294**

Land degradation

A FAO study on future need of agricultural land (1982) provides the important statistics (see Table 5) relating to agricultural land use in the developed and developing countries.

Table 5
Land requirements for agriculture

Land use category	Area distribution		
	Developing	Developed	Total
	(million ha and %)		
Potentially cultivable area	2 154	877	3031
(% of land area)	(28)	(15)	(26)
Currently (1990) cultivated area	776	666	1442
(% of potential)	(36)	(77)	(48)
Persons per ha of currently cultivated land	5.0	2.0	4.0

Source: FAO Agrostat database

In the developed countries, it is most likely that no new land will be needed for agriculture during 1990-2020. The additional population, in any case, will be rather small. Owing to improved inputs and technology, the per caput need for agricultural land may in fact decline further as the past trend suggests.

The scenario is quite different for the developing countries. The pressure on agricultural land is expected to increase significantly by the year 2020 as compared to 1990. The scarcity of capital for intensive agriculture, as well as the availability of new cultivable land will be the main limiting factors.

The extension of cultivated area in the developing countries, to be sustainable, will require fresh capital. Generally, the more marginal the land, the higher the level of inputs required. Due to the scarcity of capital, the level of inputs in agriculture tends generally to be low. Adequate soil conservation measures are not usually applied. It is estimated that the developing countries are losing annually about 1% of their prime agricultural land (personal communication by FAO, Agriculture Department). The lack of capital leads to a lack of proper soil conservation measures which, in turn, leads to land degradation. This consequently increases the per caput need for agriculture: a vicious circle.

In conclusion, the risk of deforestation in the developing countries is very high. Unless serious efforts are made to meet the basic needs of the population with minimum damage to environment, the consequence will be a spiraling rise in deforestation and forest degradation.

Volume and biomass

The growing stock of global forests is estimated at 384 billion m^3 overbark corresponding to an average of 114 m^3/ha which is almost the same in the developing as in the developed countries (see Table 6). The distribution of total volume is also in the same proportion as the forest area, about 58:42. In terms of biomass, the ratio between developing and developed countries is 75:25. This is mainly attributed to the higher density of wood and higher percentage of branch wood in the tropical forests. The distribution of volume per caput, as expected, is very uneven (see Figure 4), ranging from 244 m^3/inh in Latin America and the Caribbean to 19 m^3/inh in the Asia and Pacific Region.

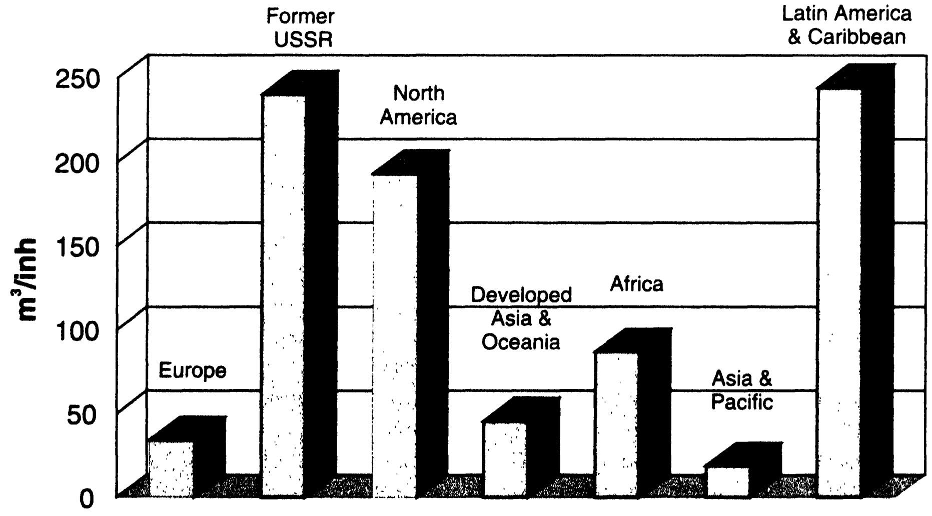
The growing stock/ha in the last 30 years has steadily increased in almost all of the developed countries. In North America, Europe, Japan, Australia and New Zealand the net annual increment has been higher than fellings even though such countries reported an increasing trend in annual fellings as well.

In the developing countries, two groups of processes namely deforestation and forest degradation, are re-enforcing and contributing towards a decrease in the total growing stock. In addition to the net loss of forest area and associated stock, there has also been a reduction in the volume per hectare of the remaining forest, where removals exceed growth: a vicious circle again.

Table 6
Volume and biomass distribution at the year 1990

Region	Area	Volume			Biomass		
	million ha	*m³/ha*	*Total million m³*	*Per Caput m³/inh*	*tons/ha*	*Total million tons*	*Per Caput tons/inh*
Europe	149	129	19 264	34	79	11 864	21
Former USSR	755	112	84 234	240	68	51 648	147
North America	457	117	53 401	193	98	44 948	163
Developed Asia & Oceania	71	92	6 553	46	58	4 137	29
Developed regions	**1 432**	**114**	**163 451**	**122**	**79**	**112 598**	**84**
Africa	541	103	55 655	87	134	72 306	113
Asia & Pacific	441	125	55 200	19	171	75 269	26
Latin America & Caribbean	960	114	109 421	244	188	180 307	403
Developing regions	**1 941**	**113**	**220 276**	**55**	**169**	**327 882**	**82**
ALL REGIONS	**3 374**	**114**	**383 727**	**72**	**131**	**440 479**	**82**

Figure 4
Volume per caput by region



Global Climate Change

The possibility of global climate change, due to increases in the level of carbon dioxide and other greenhouse gases in the Earth's atmosphere which are largely the result of human activities, is one of today's key environmental concerns. The rate of exchange of carbon between the earth's surface, the oceans and the atmosphere, known as the carbon cycle, is the primary driving force with regard to possible climate change. Through the process of photosynthesis, green plants absorb carbon dioxide from the atmosphere. Trees and forests store the absorbed carbon in woody biomass. Approximately 50% of dry woody biomass is carbon. Therefore, changes in land cover, which result in changes in the woody biomass, will have direct effects on the rate of carbon released into the Earth's atmosphere.

Dixon et al (1994) have made use of the FAO tropical deforestation data base and related information to produce new estimates of the amount of carbon stored in forests and the net influence of forests in the present day global carbon cycle. Their conclusion is that the world's forests are presently a net source of atmospheric Carbon Forests in the high and mid latitudes presently store 0.74 ± 0.1 petagrams (Pg = 10^{15}g) of carbon per year. The forests of the low latitudes (largely tropical forests), on the other hand, presently contribute approximately 1.65 ± 0.4 Pg carbon to the earth's atmosphere. This results in a net annual contribution of 0.9 ± 0.4 Pg carbon from forests, largely due to deforestation associated with land use change in the tropics. This is equivalent to about 16% of the carbon emissions from burning fossil fuels by e.g., industry and transport sectors, currently estimated to be about 5.5 Pg/year.

Forest sector contributions to atmospheric carbon dioxide can be reduced through a number of measures including slowing the rate of deforestation, increasing forest productivity through intensified management and protection, and establishment of forest plantations. For maximum effectiveness, these actions must be part of an integrated programme designed to reduce emissions of greenhouse gases from all sectors.

It is important to note that estimates of carbon used by scientists concerned with climate change include not only that of the above ground biomass of stems and branches but also carbon stored in roots, non-tree vegetation, soil organic matter, coarse woody debris and fine litter.

Reliable estimates of global biomass plays an important role in providing a better understanding of the impact of deforestation and land use change on the environment. For this purpose, an indication of data reliability is a must in order to distinguish the real changes from spurious changes arising from errors in reported data.

The state of forest management

The term "forest management" is used here in a wider sense, to include both the production and conservation functions of forests.

Since the World Forest Inventory in 1963, there has been an all-round improvement in forest management in developed countries. This is evident from the rise in growing stock per ha and the increase of net annual increment despite the higher level of removals per ha mentioned earlier. On the other hand, the total area under active management has declined in developing regions. FAO then reported a managed forest area of 89 million ha. According to the present assessment, the area of tropical forests managed in some form or another is estimated to be 60 million ha. Though working plans exist for these forests, prescriptions are not generally being implemented due to lack of funds and forests are undergoing a slow process of degradation, owing to the lack of silvicultural treatment, heavy grazing and over-exploitation for timber or for fuelwood by the local population (FAO 1993).

The above development is understandable because in many countries land use practices have not yet stabilized. Due to economic problems, which constitute the most important reason, adequate funds to support forest management, which is a long-term undertaking, are not forthcoming. Joint forest management, involving the local community in forest planning, is gaining momentum in several countries of the tropics. It should result in an increase of the forest area under sustainable management in developing countries.

Trends in wood consumption

The total roundwood consumption on a global basis increased from 1900 million m^3 in 1961 to 3 429 million m^3 in 1991, as shown in Table 7. Fuelwood and charcoal was the dominant form of wood use in the developing countries (about 80%), whereas it constituted only 16% of the total roundwood consumption in the developed countries. The pattern of wood consumption did not change significantly in either the developing or developed countries during the last 30 years.

The FAO projections indicate a rising trend on a global basis, in the consumption of industrial Roundwood from 1 599 million m^3 in 1990 to

Table 7
Roundwood consumption

Category	Units	Developed countries 1961	Developed countries 1991	Developed countries 2010	Developing countries 1961	Developing countries 1991	Developing countries 2010	Total 1961	Total 1991	Total 2010
Fuelwood/charcoal	million m^3	256	236	278	623	1 594	2 117	879	1 830	2 395
	(% of Total)	(23%)	(16%)	(13%)	(78%)	(80%)	(73%)	(46%)	(53%)	(47%)
Industrial roundwood	million m^3	844	1 210	1 875	177	389	799	1 021	1 599	2 674
	(% of Total)	(77%)	(84%)	(87%)	(22%)	(20%)	(27%)	(54%)	(47%)	(53%)
Total Roundwood	million m^3	1 100	1 446	2 153	800	1 983	2 916	1 900	3 429	5 069
	(% of Total)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)

2 674 million m^3 in 2010, and in the consumption of fuelwood/charcoal from 1 830 million m^3 to 2 395 million m^3 in the same period.

Conservation and Biodiversity

The areas currently protected, based on assessments by the World Conservation Monitoring Centre (WCMC 1993), are given in Table 8. According to WCMC, it is often difficult to know from the available data whether or not a conservation area network is operating effectively, particularly in terms of biodiversity, and its extent of forest cover. Conservation areas have frequently been established with little or no regard for the ecological criteria in their selection. Continuing and growing pressure on land throughout the tropics, particularly in densely populated Asian nations, has forced the selection of conservation areas to be made on pragmatic rather than scientific grounds.

The biological diversity needs to be evaluated and conserved at the ecosystem, species and gene levels. The "forest principles", formulated refer to "management, conservation and sustainable development of all types of forests" of the world. To implement these principles, and, in particular to conserve the main ecosystems of the world effectively, it is essential that a worldwide zoning of forest types and mapping out of the remaining

Table 8
Distribution of protected areas[1] *(at least 1,000 ha)*

	All		Totally protected (category I&II)		Partially protected (category III, IV & V)	
	number	*million ha*	*number*	*million ha*	*number*	*million ha*
WORLD	**8 619**	**792**	**2 546**	**465**	**6 073**	**328**
Developing	**3 281**	**486**	**1 164**	**296**	**2 117**	**190**
Africa	704	139	260	91	444	48
Latin America	1 071	231	498	170	573	61
Asia	1 506	116	406	35	1 100	81
Developed countries	**5 338**	**306**	**1 382**	**169**	**3 956**	**137**
Europe	2 177	46	298	9	1 879	37
Former USSR	218	24	164	24	54	0
North America	1 348	147	422	66	926	81
Oceania/Asia	1 595	89	498	70	1 097	19

Source: WCMC 1993

[1] Categories are defined in Annex 2.3.

vegetation is accomplished to constitute an informed basis for further action on conservation. The classification and mapping need to have worldwide coverage, to accurately identify unique types of vegetation cover on a sub-regional/regional basis, and to locate natural forests of which only limited areas remain intact, the rest having been drastically altered or modified by man. It would also be desirable to extend the coverage to other wooded lands (and not only forests). Furthermore, distinction will be necessary between natural and man-made or drastically altered natural vegetation types as these two types of vegetation have different genetic histories.

The species richness (i.e. the total number of species in a geographic area), based on data compiled by WCMC (1992), is given by region and sub-region in Table 9. These statistics show a significant level of species richness in the developed as well as in developing countries.

Table 9

Distribution of higher plants (including ferns, cycads, conifers and broad leaved species) by region and sub-region [1]

Regions	**Total number of species**
Latin America	85 000
Africa	45 000 - 40 000
North Africa	10 000
Tropical Africa	21 000
Southern Africa	21 000
Tropical & subtropical Asia	50 000
India	15 000
Insular Asia	30 000
China	30 000
Australia	15 000
Mediterranean basin	25 000
North America	17 000
Europe	12 500
WORLD	**270 000**

Source: Global Biodiversity - WCMC (1992)

[1] As subregions may have common species, the numbers cannot be added to make regional totals.

The conservation of biodiversity is a need shared equally by both developed and developing countries. Demographic pressure and the growing demand for farmland and settlements, for timber and fuel, mining, and transportation networks had similar effects on forests in former times on what today constitute developed regions — precisely the case at present in the developing world. Major changes in vegetation took place in the Mediterranean basin more than 2 000 years ago, in Europe in the Early and Middle Ages, and in North America in the 17-19th centuries. Owing to these large-scale land-use transformations, conservation of the remaining natural vegetation and its rehabilitation within a global framework presents a challenging task.

A model study on the risk of biodiversity loss associated with deforestation in tropical forests was conducted as part of the Forest Resources Assessment 1990 Project. Use was made of geo-referenced information, including eco-floristic zone and natural vegetation maps and demographic data over time at the sub-national level (see Figure 5). Species richness was computed by ecological zone. The risk of species richness loss associated with deforestation was then estimated. As could be expected, the tropical Asian region was identified as the most threatened (FAO 1993). This can be expected because the region has a limited remaining area of natural forests, which are prone to further deforestation under relatively high population pressure. Clearly, there is an urgent need to extend such studies on a global basis in order to provide the basis for undertaking timely and effective conservation measures. The selection of conservation areas must be carried out on the basis of current settlement patterns and future demographic evolution, and how these factors relate to the size of the forest area to be conserved and managed under the multiple-use concept.

2

DEVELOPED COUNTRIES

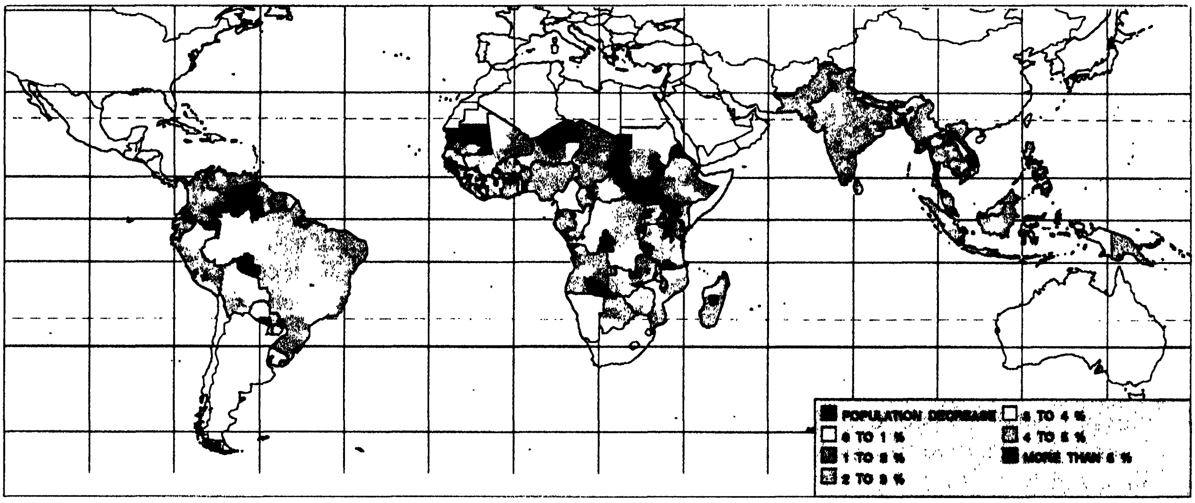
This part of the global assessment covers all the countries of Europe, the former USSR, Canada, the United States, Australia, Japan and New Zealand. These account for a major part of the temperate forests of the world. In the northern hemisphere, three main forest types can be distinguished: the boreal forest to the north, consisting predominantly of conifers; a central band of mixed temperate forests, where broadleaves are in the majority; and the Mediterranean-type forests, also predominantly broad-leaved, in the warmer, drier areas to the south. Australia and New Zealand, separated for millennia from the rest of southeast Asia, have their

Table 10
Summary of forest resources statistics by region for developed countries

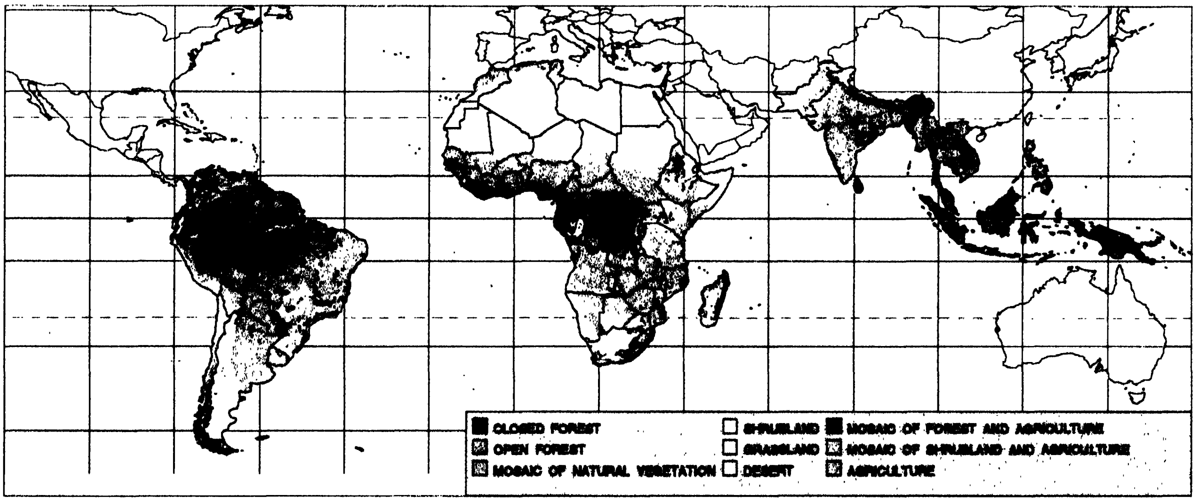
Country	Forest and other wooded land			Forest					Exploitable (production) forest			Above ground	Net annual increment		Fellings	Annual Fellings/ increment
	Total	Percent of	Per caput	Total	Percent of forest & other wooded land	Exploitable (production)	Unexploitable (non-production)	Other wooded land	Total	Per hectare	Percent coniferous	(oven dry)				
	million ha	*%*	*ha/cap*	*million ha*	*%*	*million ha*	*million ha*	*million ha*	*billion m^3 o.b.*	*m^3 o.b./ha*	*%*	*billion tons*	*million m^3 o.b.*	*m^3 o.b./ha*	*million m^3 o.b.*	*Fellings as % of NAI*
Former USSR	942	44	3.26	755	80.1	414	341	187	50	122	74	94	700	1.7	518	74
North America	749	40.8	2.71	456	60.9	308	148	293	38	123	64	52	968	3.2	771	80
Europe	195	35.4	0.35	149	76.4	133	16	46	19	139	64	12	577	4.3	408	71
Australia, Japan & New Zealand	178	21.7	1.24	72	40.4	43	29	106	5	117	47	5	163	3.8	83	51
TOTAL	**2 064**	**38.6**	**1.62**	**1 432**	**69.4**	**898**	**534**	**632**	**112**	**125**	**68**	**163**	**2 408**	**2.6**	**1 780**	**74**

Sources: FAO. UN-ECE/FAO
billion = thousand million

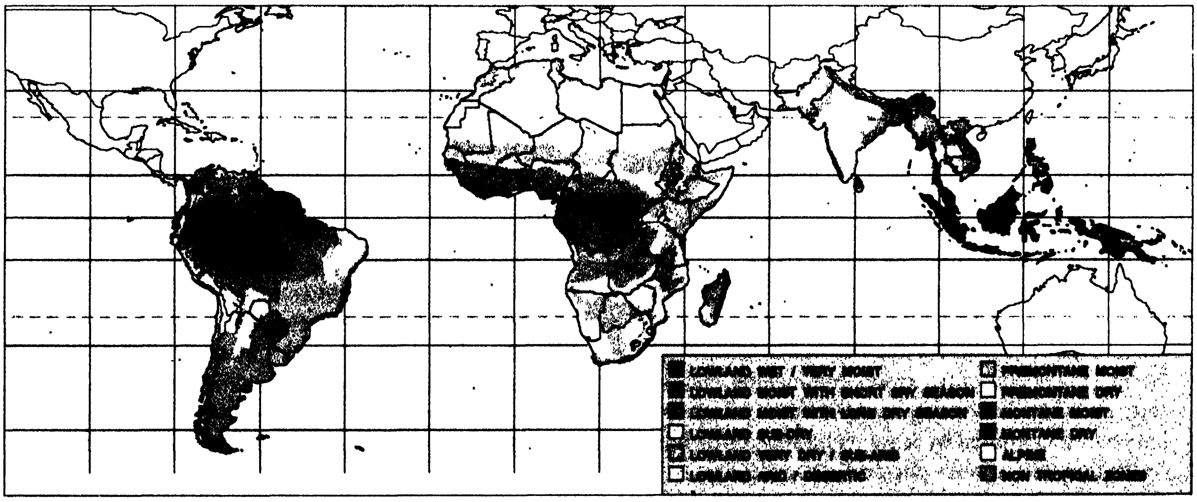
Figure 5
Main geo-referenced data used in assessing the risk of loss of biodiversity in the tropics.
(Originals are at 1:5 000 000 scale)



HUMAN PRESSURE - POPULATION GROWTH 1981-90


CLOSED FOREST
OPEN FOREST
MOSAIC OF NATURAL VEGETATION
SHRUBLAND
GRASSLAND
DESERT
MOSAIC OF FOREST AND AGRICULTURE
MOSAIC OF SHRUBLAND AND AGRICULTURE
AGRICULTURE

MAIN VEGETATION FORMATIONS



ECOLOGICAL ZONES

own specific forest flora, which ranges from moist tropical forest through to temperate forest Savannah-type woodland.

Distribution of forest and other wooded land

The main distinction in woody vegetation made in the 1990 assessment for developed countries was between *forest* and *other wooded land*, on the basis of the definition that forest land should have a tree cover of more than 20 percent with trees usually growing to more than 7 metres in height. Other wooded land includes open woodland and scrub, shrub and brushland. The area of forest and other wooded land in the developed countries amounted, according to the 1990 assessment, to 2.06 billion ha or 39 per cent of the land area. However, the share of forest and other wooded land in total land area varies widely at the country level (see Table 3: Annex 1), from 77 per cent in Finland, 69 per cent in Sweden and 68 per cent in Japan to less than 10 per cent in Iceland, Ireland, Israel, the Netherlands and the United Kingdom.

The largest concentrations of forest and other wooded land are on the territories of the former USSR, with 942 million ha, followed by North America with 749 million ha, Europe with 195 million ha, and the Pacific developed countries (Australia, Japan and New Zealand) with 178 million ha. Country detail is shown in annex 1, table 3.

With a population of 1.34 billion in the developed countries, there is an average of 1.6 ha of forest and other wooded land per caput but the variations are enormous: over 17 per caput in Canada, 3.3 in Sweden; 0.1 to 0.2 in Germany, Italy and Japan and only 0.04 in the United Kingdom and 0.02 in the Netherlands.

Forest (without other wooded lands) covers 1.43 billion ha in the developed countries or 69 per cent of total forest and other wooded land. The proportions are 77 per cent in Europe, 80 per cent in the former USSR, 61 per cent in North America, 98 per cent in Japan, 100 per cent in New Zealand and 27 per cent in Australia. The most extensive areas of other wooded land occur in Canada, the former USSR, the United States and Australia. Over four-fifths of Europe's other wooded land is found in the countries around the Mediterranean.

A distinction is also made between *exploitable forest* (shown in annex 1, Table 3) and *unexploitable forest*, the former being forest that is being harvested for wood or which has no restrictions on harvesting, and the latter where wood harvesting is limited by legal, economic or technical restrictions or where physical productivity is too low or harvesting costs too high to warrant wood harvesting on a commercial scale. There are almost 900 million ha of exploitable forest in the developed countries and 535 million of unexploitable, the largest areas of the latter being in the former USSR and Canada, which between them account for nearly 90 per cent of the total. These two countries, together with the United States, had 722 million ha of exploitable forest or 80 per cent of the developed countries' total, while there are 133 million ha in Europe and 43 million in the three Pacific developed countries. The country data given in annex 1, Table 3, are summarized by region in Table 10.

Data for the 1990 assessment were collected before the political changes in the countries of central and eastern Europe had occurred and therefore relate to the previous states. Information is available for some of the "new" states and is summarized in Table 11. It may be noted that the data in this table are not comparable with those in annex 1, Table 3 because of differences in classification. Information on other countries will become available in due course.

The most noteworthy statistic in Table 11 is that of the Russian Federation: an area of forest land of 771 million ha, which means that, even leaving aside the other newly independent states, it holds by far the largest temperate forest estate among the developed countries.

The *pattern of ownership* of forest and other wooded land is variable in the developed countries. In the former USSR and some of the former centrally planned economies of central and eastern Europe it was 100 per cent publicly owned, although that is changing with some privatization as part of the transition process. In western Europe about two-thirds of the forests are privately owned, and these holdings are in most countries of small average size (less than 4 ha on average in western Europe other than the Nordic countries and about 40 ha in the latter). The Nordic countries, Austria and Portugal have a high proportion (over 70 per cent) in private hands. Sweden, Finland, Canada and the United States are the only countries where the forest industries have large holdings. In some countries, such as France and Switzerland, municipalities are sizable forest owners, but generally the State or regional governments, e.g. the Provinces in Canada, are the main public owners. In North America, there is a marked difference between Canada where over 94 per cent of forest and other wooded land is publicly owned, and the United States where only 28 per cent of it is. Of the 72 per cent privately owned, 15 per cent is held by forest industries.

Table 11
Main forest statistics of the eastern European and Former USSR countries

Country	Total	Forest land		Growing stock	
	1000 ha	*Percent of land area*	*ha per caput*	*Total million m^3 o.b.*	*m^3 o.b. per hectare*
Former Czechoslovakia					
Czech Republic	2 637	33.4	0.26	617	234
Slovakia	1 989	40.6	0.38	360	181
Former Yugoslavia					
Croatia	2 458	43.5	0.53	298	121
Slovenia	1 077	53.2	0.54	207	192
Former USSR					
Armenia	329	11.0	0.09	39	119
Azerbaijan	992	11.5	0.14	128	129
Belarus	6 256	30.1	0.61	921	147
Estonia	1 915	42.5	1.24	243	127
Georgia	2 758	39.6	0.51	422	153
Kazakhstan	9 643	3.5	0.57	366	38
Kyrgystan	729	3.7	0.16	23	32
Latvia	2 757	42.7	1.05	439	159
Lithuania	1 959	30.0	0.52	321	164
Rep of Moldova	315	9.3	0.07	35	111
Russian Federation	771 109	45.2	5.20	81 644	106
Tajikistan	410	2.9	0.08	6	15
Turmenistan	4 127	8.5	1.12	14	3
Ukraine	9 239	15.3	0.18	1 320	143
Uzbekistan	1 909	4.3	0.09	11	6

Source: Prins, K. & Korotkov, A., 1994

Changes in area of forest and other wooded land

Official data on changes during the 1980s could not be provided by all developed countries, but the picture that emerges is of a *net* gain in area of forest and other wooded land in Europe of around 2 million ha over 10 years, as follows (in million ha):

Expansion of which:	+3.8
Afforestation	+2.5
Natural extension	+1.3
Shift to other uses	-1.8
Net gain	2.0

There were also increases in New Zealand and Australia, but a decrease of 3.2 million ha in the United States, mainly to make way for urban and infra-structural development. Official data are not available from Canada, but an authoritative source estimates that the net change in forest area over the past decade was negligible.

The former USSR reported a net increase in forest and other wooded land of 22.6 million ha between 1978 and 1988. However, another authoritative source reports an increase in forest area by 21.7 million ha, partly offset by a decrease in other wooded land of 11.1 million ha. In view of these conflicting reports, estimates of forest area change for the former USSR have not been included in annex Table 4.

The problems of obtaining reliable data on area changes for the developed countries and the need to improve this situation, given the increasing interest in such information, are discussed in annex 2 which describes methodologies.

Growing stock and woody biomass

The standing volume of forest and tree resources, (including, in some cases, trees outside the forest) in the developed countries has been estimated at around 170 billion m^3 overbark (o.b.). This is certainly an underestimate, as it does not include large volumes that are not covered by the inventory in some countries, e.g. for trees outside the forest. A more realistic estimate of volume may be well over 200 billion m^3 o.b. Standing volume comprises growing stock and dead trees; the latter are a relatively small proportion in managed forests, but more significant in natural stands.

The volume of growing stock on exploitable forest in the developed countries is estimated at 112 billion m^3 o.b., of which 45 per cent in the former USSR and 34 per cent in North America. Coniferous species account for 68 per cent of the total, but the share varies considerably from country to country. In the former USSR and Canada it is around three-quarters and in the Nordic countries and Austria over 80 per cent. On the other hand, Hungary has 85 per cent broadleaves, and other countries with substantial shares of broadleaves are France and Romania with around 60 per cent, former Yugoslavia with 70 per cent, the United States with 43 per cent and Australia with 85 per cent.

The volume of growing stock per hectare, which is dependent on growing conditions but also on management policies and objectives, varies widely. In the developed countries the growing stock per ha of exploitable forest averages 125 m^3, but in some parts of central Europe it exceeds 300 m^3, while in areas with less favorable growing conditions it is under 100 m^3 per ha.

Since the time of the first energy crisis in the early 1970s, interest has grown in the potential for biomass in general and wood in particular to make a greater contribution to total energy supply. In the developed countries, wood's share is still very small, although looked at from another angle, namely the share of total wood removals that sooner or later finishes up by being used for energy purposes, whether as fuelwood, chips, forest and industrial residues, pulping liquors, or recycled wood and paper products, is significant: it has been estimated to be as much as two-fifths in Europe.

The frequently used methodology for deriving estimates of woody biomass is described in annex 2 on methodology. However approximate the results may be, they do give a general order of magnitude, which can be summarized as follows (estimated mass of above-ground standing volume of biomass in billion oven-dry metric tons):

Developed countries total	117
Former USSR	94
North America	52
Europe	12
Other	5

Increment and fellings

Up to now, inventory information on increment could be measured only for forests under regular management and has in consequence been obtained mainly for the developed countries. Furthermore, as for growing stock, information is more complete for exploitable forest than for other parts of the forest resource. Net annual increment is estimated at 2.4 billion m^3 o.b. on exploitable forest in the developed countries, of which 968 million in North America, 700 million in the former USSR, 577 million in Europe and 163 million in the Pacific developed countries. Net annual increment per hectare varies greatly for the same reasons as for growing stock, mentioned above, but in addition it is heavily dependent on the intensity of management. In natural, unmanaged and mature or over-mature stands, such as exist over large parts of the former USSR and Canada, natural mortality may more or less equal gross increment, leaving a negligible volume of net increment. This explains the low net annual increment figures for those two countries, 1.7 and 1.9 m^3 o.b./ha/year respectively, compared with an average estimated at 2.6 for the developed countries as a whole, 4.3 for Europe and 3.9 for the United States.

Data on wood production (fellings, removals) collected in connection with forest inventories provide indications of the wood drain on the forest and allow comparison with other parameters, such as increment. A distinction is made between fellings and removals, the difference being the volume of timber felled but not extracted from the forest. Total fellings in the developed countries around 1990 are estimated at approximately 1.9 billion m^3 o.b., which is probably an under-estimation. Coniferous species accounted for two-thirds of the total.

A comparison of fellings with net annual increment on exploitable forest, which accounts for over 90 per cent of the total and for which the data are the most reliable, provides an interesting indicator of the level of harvesting intensity, although it should be underlined that net annual increment cannot be equated with allowable cut. The latter may be higher or lower than increment, depending on a number of factors, one of the most important being the age-class distribution of the stands. In all the developed regions, and in practically all developed countries, fellings have remained below net annual increment, in some cases by a substantial margin. Fellings in 1990 on exploitable forest in the developed countries of an estimated 1.78 billion m^3 o.b. compare with the estimate given above of 2.4 billion for net annual increment. Fellings were thus 26 per cent less than increment, and there are differences of a similar magnitude in the regions: 20 per cent in North America; 26 per cent in the former USSR; 29 per cent in Europe; and perhaps as much as 50 per cent in the three Pacific countries together. This does not seem to be a new development, and indeed there is evidence that increment in Europe has exceeded fellings for 40 years at least, and probably for a much longer period, thus explaining why there has been a long-term build-up in growing stock in Europe.

It would seem that even in countries where the area of exploitable forest has been declining, such as the United States, total growing stock on the remaining area has been rising, especially of broadleaves. In Canada also, additions to growing stock are estimated to have exceeded fellings and natural losses by 69 million m^3 annually between 1977 and 1986.

Environmental and other non-wood goods and services of the forest

An attempt was made to assess the role of forests of developed countries in supplying environmental and other non-wood goods and services (non-wood benefits) information. The results of this part of the assessment are discussed in more detail in Chapter III (Special issues), while the methodology employed for collecting information is described in annex 2. A summary of results is presented here. One most obvious conclusion is that generalizations are impossible, given the diversity of the replies on the benefits and functions of the forest from countries, which can be attributed to varying conditions such as extent of forest cover, population density, topography, standards of living and so on, as well as differences in approach to answering the questionnaire by national correspondents.

Developed countries' responses are unanimous, however, in showing that the environmental and other non-wood goods and services of the forest are of increasing importance to society, both in absolute terms and relative to wood production. Nonetheless, the latter remains the single most important function of the forest nearly everywhere. Although it is not possible to rate the relative importance of the different functions, even at country level, or to aggregate the replies, they suggest that after **wood production**, the most important are **hunting, recreation and protection**.

The majority of countries expect increasing emphasis in policy and planning to be given to the non-wood functions of the forest, in particular **protection, water regulation and quality, nature conservation, including protection of biological diversity, and recreation**. The prevailing importance of wood production will be maintained, while the importance of hunting, grazing and the supply of certain specified non-wood products will also remain about the same as in the past. The implication is that policies for the multiple use of the forest will be strengthened, and furthermore forests will be expected to provide not only a wide range of goods and services but to do so more nearly to the limits of their capacity on a sustainable basis.

The assessment also showed that public attitudes towards the forest and forestry have been changing over the past decade, with increasing concern being expressed in many countries for the protection of the environment, conservation of forests, biological diversity and meeting society's demands for non-wood benefits. Conflicts do arise between different functions of the forest, most commonly between wood production and one or more of the other functions, notably environmental protection, hunting, nature conservation and recreation. Forest policies of a growing number of countries take this into account, and methods are being improved for reconciling such conflicts.

Conclusion

Of the main findings of the 1990 forest resource assessment of the developed countries, two stand out as being common to most of them, so far as their significance for the long term and likely implications for policy are concerned. They are:

1) the continuing expansion of the forest resource, notably in terms of growing stock but also in most countries of area as well; and
2) the increasing importance, in relative as well as absolute terms, of the non-wood functions of the forest.

3
DEVELOPING COUNTRIES

Source data as well as data in various stages of processing are stored in FAO's FORIS database. This database is an important output of the assessment process and marks the starting point of tropical forest resources assessment on a continuing basis. Using the database, it is possible to make a study of historical trends and future prospects. As more multi-date observations become available and are added to the database, the precision of estimates, particularly of change rates, is expected to increase.

State of forest area and rate of change

As described in the methodology (Annex 2), the estimations of forest area and changes have been made at subnational level. Results are then aggregated at national level for reporting purposes. The national estimates are further aggregated at subregional, regional and global tropical levels as presented in tables in the Annex.

It is important to note the distinction between forest and plantation made in the assessment of developing countries. While the term "forest" refers to a formation of natural origin, "plantation" implies an artificially established crop involving the replacement of the indigenous species by a new and essentially different species or genetic variety (see Annex 2.3: Definitions).

Tropical Regions

The **forest area** in the tropical regions was 1 761 million ha at end-1990 compared with 1 916 million ha at end-1980. Thus, the average annual deforestation during the past decade amounts to 15.4 million ha, a compound annual rate of deforestation of 0.8 per cent. The largest extent of forest area was in Latin America and the Caribbean (918 million ha; 52 per cent of the total tropical forest area), followed by Africa (528 million ha; 30 per cent), and Asia and Pacific (315 million ha; 18 per cent). The annual loss of forest area by region was: Latin America and the Caribbean 7.4 million ha (0.8 per cent), Africa 4.1 million ha (0.7 per cent), and Asia and Pacific 3.9 million ha (1.2 per cent) as given in Annex 1: table 4.

Among the subregions, the following have relatively high rates of deforestation: East Sahelian and West Africa, Tropical South Africa; Continental and Insular Asia; Central America and Mexico.

Non-tropical Regions

The estimated forest area at end 1990 was 180 million ha (6.4% of land); in addition there were 111 million ha (4% of land) of other natural woody vegetation (mainly shrubs).

The more forested sub-regions are South America (11.6 % of land) and Temperate Asia (14.0 %). In North Africa and Middle East the present natural forest cover is less than 1 %.

In absolute term the bulk of natural forests are located in Asia (mainly in China. The second important sub-region is South America, as shown in the Annex 1: table 4.

The estimated annual loss of natural forest cover was 0.85 million ha (0.5 percent) which is lower than the deforestation rate estimated for tropical countries (0.8 percent).

Comparison with the 1980 Assessment.

It is of interest to compare the forest area estimates for the base year 1980 made by the FAO 1980 and FAO 1990 assessments.

The current estimate of the 1980 forest cover is 2 105 million ha against the earlier figure of 2 125 million ha, i.e. about 20 million ha less. The area of forest and other wooded lands is now estimated at 3 117 million ha against the earlier figure of 3 267 million ha, i.e. 150 million ha less. These changes in the baseline figures illustrate the problem involved in comparing the estimates of deforestation in successive rounds of assessment.

Differences in the estimates of the 1980 forest cover between the two assessments arise mainly from two factors: the increased amount of information in the 1990 assessment relating to 1980 and following years; and the improved procedures for updating estimates at different years employed in the more recent assessment.

State of forest biomass and assessment of change

Country estimates are given in annex 1, table 5, and a summary in table 14. The Caribbean, Central Africa and Insular South East Asia subregions have still more than 200 tons of biomass per hectare on average, whilst the lowest values are found in tropical Southern Africa and in Sahelian Africa. It may also be noticed that the biomass per caput values are extremely low in South Asia due to very high population pressure. Low values are also found in West Africa, Sahelian Africa and Central America. It is remarkable that the average biomass per caput of Asia is only one fourth that of Africa and less than one tenth that of Latin America and the Caribbean.

Table 12
Estimates of forest area and rate of deforestation by geographical subregion

Geographical subregion / region	Number of countries	Land area	Forest cover		Annual deforestation 1981-90	
			1980	1990		
		million ha			million ha	% per annum
Africa	**40**	**2 236.1**	**568.6**	**527.6**	**4.10**	**0.7**
West Sahelian Africa	9	528.0	43.7	40.8	0.30	0.7
East Sahelian Africa	6	489.7	71.4	65.5	0.60	0.9
West Africa	8	203.8	61.5	55.6	0.59	1.0
Central Africa	6	398.3	215.5	204.1	1.14	0.5
Tropical Southern Africa	10	558.1	159.3	145.9	1.35	0.9
Insular Africa	1	58.2	17.1	15.8	0.14	0.8
Asia & Pacific	**17**	**892.1**	**349.6**	**310.6**	**3.90**	**1.2**
South Asia	6	412.2	69.4	63.9	0.55	0.8
Continental S.E. Asia	5	190.2	88.4	75.2	1.31	1.6
Insular S.E. Asia	5	244.4	154.7	135.4	1.93	1.3
Pacific	1	45.3	37.1	36.0	0.11	0.3
Latin America & Caribbean	**33**	**1 650.1**	**992.2**	**918.1**	**7.41**	**0.8**
C. America & Mexico	7	239.6	79.2	68.1	1.12	1.5
Caribbean	19	69.0	48.3	47.1	0.12	0.3
Tropical South America	7	1 341.6	864.6	802.9	6.17	0.7
TOTAL TROPICAL	**90**	**4 778.3**	**1 910.4**	**1 756.3**	**15.41**	**0.8**
Non-tropical Africa	**8**	**727.2**	**14.3**	**13.0**	**0.13**	**0.9**
Northern Africa	5	600.3	6.4	5.7	0.07	1.2
Southern Africa	3	126.9	7.9	7.3	0.06	0.8
Non-tropical Asia	**17**	**1 712.4**	**130.2**	**125.7**	**0.44**	**0.4**
Middle East	13	601.2	3.8	3.3	0.04	1.2
Temperate Asia	4	1 111.2	126.4	122.4	0.40	0.3
South America	**3**	**366.0**	**44.3**	**41.6**	**0.27**	**0.6**
TOTAL NON TROPICAL	**28**	**2 805.6**	**188.8**	**180.2**	**0.85**	**0.5**
TOTAL DEVELOPING	**118**	**7 583.9**	**2 099.2**	**1 936.5**	**16.27**	**0.8**

Source: FORIS database

Annual loss of biomass is estimated at slightly over 2 500 million tons, of which nearly 50 per cent is contributed by the Latin American region, nearly 30 per cent by tropical Asia and about 20 per cent by tropical Africa.

The average biomass density in the non-tropical developing regions is estimated to be 170 tons/ha, and the annual loss to be 152 millions of tons corresponding to 0.9 millions of hectares of annual deforestation.

The state of Forest Ecosystem

The report on the state of forest ecosystems, as presented in this section, is an important element of assessment of biological diversity. Combined with data on species richness, the estimate of area losses by ecosystem can be used to make indicative estimates of the risk of loss of species richness.

For the present reporting, the ecofloristic zones were grouped into broad forest formations: one upland and three lowland for the tropics and only one formation for the non-tropics. (see Table 15)

Table 13

Comparison of 1980 natural forest area estimate by the FAO 1980 assessment as published in *An interim report on the state of forest resources in the developing countries* and the FAO 1990 assessment published in the present report

Estimate	1980 FAO assessment	1990 FAO assessment
	million ha	
Natural forests		
Tropical (125 countries)	1 926	1 761
Non-tropical (28 countries)	199	180
Total (143 countries)	2 125	1 941
Other wooded lands		
Tropical (125 countries)	1 055	936
Non-tropical (28 countries)	87	111
Total (143 countries)	1 142	1 047
Total natural woody vegetation		
Tropical (125 countries)	2 981	2 697
Non-tropical (28 countries)	286	291
Total (143 countries)	3 267	2 988

Source: FORIS Database

Table 14

State of forest biomass and annual losses due to deforestation

Region	Forest cover area 1990	Forest biomass			Annual loss due to deforestation 1981-90		
		Average per ha	Total	Average per caput	Area	Biomass	
	million ha	*tons / ha*	*10^6 tons*	*t/person*	*million ha*	*million tons*	*% of total*
Africa	**527.7**	**133**	**70 201**	**144**	**4.1**	**479**	**18**
West Sahelian Africa	40.8	64	2 628	62	0.3	19	1
East Sahelian Africa	65.5	80	5 254	43	0.6	48	2
West Africa	55.6	97	5 409	34	0.6	57	2
Central Africa	204.1	227	46 349	878	1.1	259	10
Tropical Southern Africa	145.9	60	8 824	93	1.3	81	3
Insular Africa	15.9	109	1 737	122	0.1	15	1
Asia & Pacific	**315.4**	**181**	**57 149**	**36**	**3.9**	**737**	**28**
South Asia	63.9	100	6 368	6	0.6	55	2
Continental South East	75.2	187	14 075	80	1.3	246	9
Insular South East	135.4	213	28 837	110	1.9	410	15
Pacific	40.8	193	7 870	1 297	0.1	26	1
Latin America & Caribbean	**918.1**	**185**	**169 847**	**425**	**7.4**	**1 303**	**49**
Central America & Mexico	68.1	95	6 483	55	1.1	106	4
Caribbean	47.1	247	11 640	331	0.1	30	1
Tropical South America	802.9	189	151 723	615	6.2	1 167	44
ALL TROPICAL REGIONS	**1 761.2**	**169**	**297 197**	**121**	**15.4**	**2 519**	**94**
NON TROPICAL REGIONS	**180.2**	**170**	**30 685**	**20**	**0.9**	**152**	**6**
TOTAL DEVELOPING	**1 941.5**	**169**	**327 882**	**82**	**16.3**	**2 671**	**100**

Source: FORIS database

Table 15
Estimates of forest cover area and rate of deforestation by main ecological zone

Ecological zone	Land area	Population density 1990	Annual pop. growth 1981-90[1]	Forest cover 1990		Annual deforestation 1981-90[1]	
	million ha	inh / km^2	% per annum	million ha	% land area	million ha	% per annum
Forest zone	**4 189.7**	**57**	**2.4**	**1 748.2**	**42**	**15.3**	**0.8**
Lowland formations	**3 476.6**	**57**	**2.3**	**1 543.9**	**44**	**12.8**	**0.8**
Rainforest	937.1	41	2.2	718.3	76	4.6	0.6
Moist deciduous	1 298.6	55	2.4	587.3	46	6.1	1.0
Dry and very dry	1 241.0	70	2.3	238.3	19	2.2	0.9
Upland formations (hill and mountain forest)	**713.1**	**56**	**2.6**	**204.3**	**29**	**2.5**	**1.1**
Non-forest zone (Alpine areas deserts)	**588.6**	**15**	**3.1**	**8.1**	**1**	**0.1**	**1.0**
TOTAL TROPICS [2]	**4 778.3**	**51**	**2.4**	**1 756.3**	**37**	**15.4**	**0.8**
TOTAL NON TROPICS	**2 805.6**	**55**	**1.6**	**180.2**	**6**	**0.9**	**0.5**
TOTAL DEVELOPING	**7 583.9**	**52**	**2.1**	**1 936.5**	**26**	**16.3**	**0.8**

The table includes 118 countries as listed in table 12.

[1] Compound interest formulae were used for population growth and deforestation rate calculations.

[2] Totals may not tally due to rounding.

Source: FORIS database

At end 1990 tropical lowland formations covered 1 544 million ha (88 percent of the total tropical forest area) and upland (hill and montane) formations 204 million ha (12 percent). Among the lowland formations, the tropical rainforests constituted the largest portion, namely 718 million ha (or 41 percent), the moist deciduous forests 587 million ha (33 percent) and the dry and very dry zone forests 238 million ha (14 percent). The rest of the forests, nearly 8 million ha, were scattered in the non-forest zone.

The annual losses of forest cover by ecological zone in the tropics were: the tropical rainforests 4.6 million ha (0.6 percent), the moist deciduous forests 6.1 million ha (1.0 percent), the dry and very dry zone forests 2.2 million ha (0.9 percent) and the upland formations 2.5 million ha (1.1 percent).

Forest formations in the non-tropical regions of the developing world are very much reduced in area due to deforestation over many centuries.

The whole region extending from the Mediterranean Basin to Indus valley has been subject to intense human activity dating back to 3000 BC. Since that time several great civilizations such as Egyptian, Indian, Babylonian, Greek and Roman, all with a regional sway of power, have risen and fallen. All of them made extensive use of forest lands for human settlement and agriculture, grazing by domestic animals; and use of wood in housing, transport, mining and metallurgy. The process has been going on for several thousands of years in a essentially forest poor region.

Similar events also took place in China. The regions in the northern and northwestern China along the Yellow River, where the Chinese first settled, were once extensively wooded. There were boundless stretches of "*tsao mu*" (grass and forest) everywhere. After more than 5 500 years of overutilization action the forests of China today are instead quite reduced.

The historical processes differ in South America, where the massive clear-cut of forest for agriculture purposes dates only few centuries and the demand for new land for agriculture and especially pasture is still active, with the agricultural frontier still expanding.

CHAPTER III
Special issues

1
EXPERIENCE IN DEVELOPED COUNTRIES IN GATHERING INFORMATION ON THE ROLE OF FORESTS IN SUPPLYING ENVIRONMENTAL AND OTHER NON-WOOD PRODUCTS AND SERVICES

In the section of Chapter 2 on the results of the 1990 forest resource assessment in the developed countries, a brief account is given of some of the main findings relating to the role of forests in providing environmental and other non-wood goods and services. The intention of this section is to show the results in a little more detail and to discuss some of the problems involved in collecting and analysing information about these goods and services. This may serve the purpose of providing guidance about the scope and methodology of carrying out future assessments in the developed countries. Changes in society, including demographic movements, rising standards of living and mobility, urbanization — and its counterpart, rural depopulation — improved educational standards, as well as results of research on potential uses of forest ecosystems, have resulted in shifts in perceptions about the purposes that forests should serve and, at the same time, in an expansion in the circle of groups and persons interested in the forest and its functions.

The multiple role of forestry, while by no means a new concept, has been more and more widely recognized and stressed, together with the need to find solutions to the problem of optimizing the combination of benefits derived by society from the forest and minimizing the conflicts. All this calls for a much wider and deeper knowledge about forest ecosystems and their potentials than is obtainable from traditional forest inventories.

The first international attempt to meet this need by collecting information about the non-wood goods and services of the forest was made in the 1980 forest resources assessment of the developed countries. This experiment was sufficiently encouraging for the decision to be taken to repeat it, with some modifications, in the 1990 assessment. The objective was to bring together as much information as countries could provide on the importance they attach to the different functions of the forest, how their importance is changing over time and how they interact or conflict with each other. Such information should be useful for planners, policy-makers, managers and others responsible for the development and conservation of the forest resource.

The approach adopted was to ask countries to provide whatever quantitative data they had on the non-wood benefits. However, given that in most cases only qualitative information would be available, descriptive accounts and expert estimates were heavily relied upon. It was recognized that, inevitably, these estimates were subjectively arrived at by the correspondents replying to the questionnaire. Despite the difficulties in handling a complex enquiry, thirty-four countries replied in varying degrees of detail; only four were not able to provide any information.

Importance of forest functions

The forest functions rated according to their importance were: **wood production; protection; water; grazing; hunting; nature conservation; and recreation**; with separate assessments for four categories of forest and ownership: **public and private forest; and public and private other wooded land**. In practice, most countries concentrated on the first two categories. The rating system of **"high", "medium" and "low" importance** is explained in the annex on methodology. Because of the wide variations between countries, and even in the same country between the perceived functions of public and private forests, aggregation of countries' replies has limited relevance, but figure 6 still gives some idea of the important ratings in Europe. Wood production has the highest rating, followed by hunting and recreation.

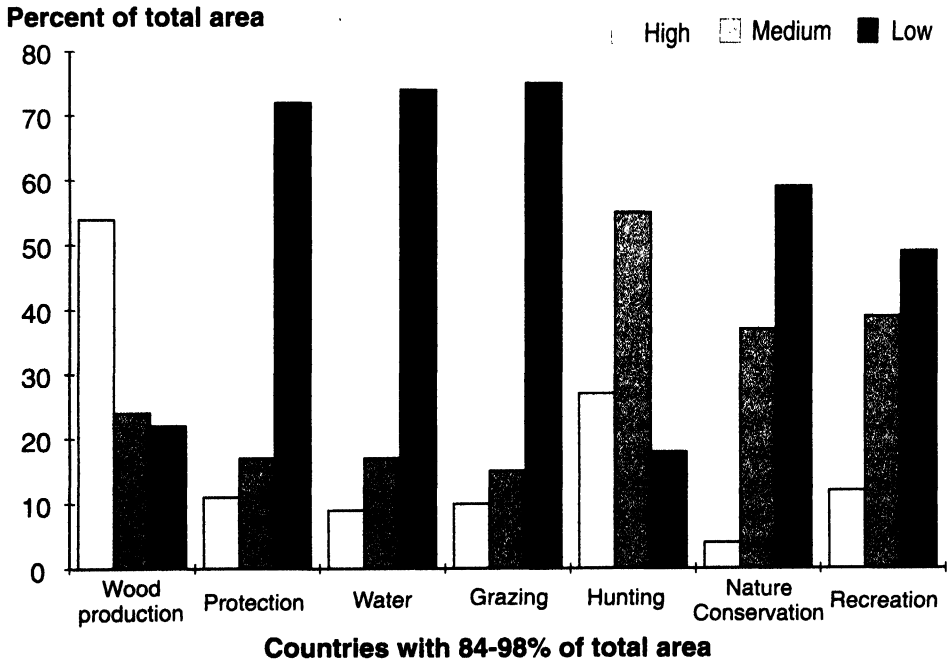
Figure 7 shows replies from selected countries for one of the functions, hunting, clearly indicating the marked differences between the high importance attached to this function in France and Poland, on the one hand, and the low importance in Ireland and the Netherlands, on the other. Similar contrasts are found for the other functions, and can generally be associated with certain factors such as type of forest, extent of forest cover, population density, topography, standard of living, and so on. The way in which national correspondents understood the questions asked and handled them in their replies also appeared to vary considerably, thereby limiting the extent to which country information is comparable.

One key question that policy-makers would like to have answered is the importance of the different functions **relative to each other**: if wood production, for example, is more important than recreation for exemple, **how much** more important is it? Such a question is impossible to answer until comparable measures, e.g. in monetary terms, of the functions are available. In any case, it may be answerable at the level of a stand or forest unit, but not for a country's forests as a whole. Until the question of comparability can be effectively handled, use will have to be made of information of the type collected in the 1990 assessment and of subjective judgements.

An alternative way of looking at the information obtained from the 1990 assessment is shown in figures 8 and 9 for Europe in aggregate, and the United States, respectively. The more convex the curves are for the different functions, the higher their importance rating. This suggests that for Europe wood production and hunting have the highest ratings, and grazing, protection and water the lowest ones; and for the United States protection, water and wood production the highest and grazing the lowest. It may be mentioned, however, that in the United States nature conservation has a convex curve (relatively high importance) in public forests but in private forest a concave one (less importance), exemplifying the point made earlier about differences in ratings that may occur between different categories of ownership. There are other examples: in Spain, the protection function is much more important in public forests than private ones; in the former Yugoslavia, grazing is more important in private forests than public; and in the United Kingdom, recreation is rated more highly in public than in private forests.

Figure 6

Importance of functions by area of public and private forest in Europe



Source: UN-ECE/FAO, 1992

National parks, nature reserves and other protected areas

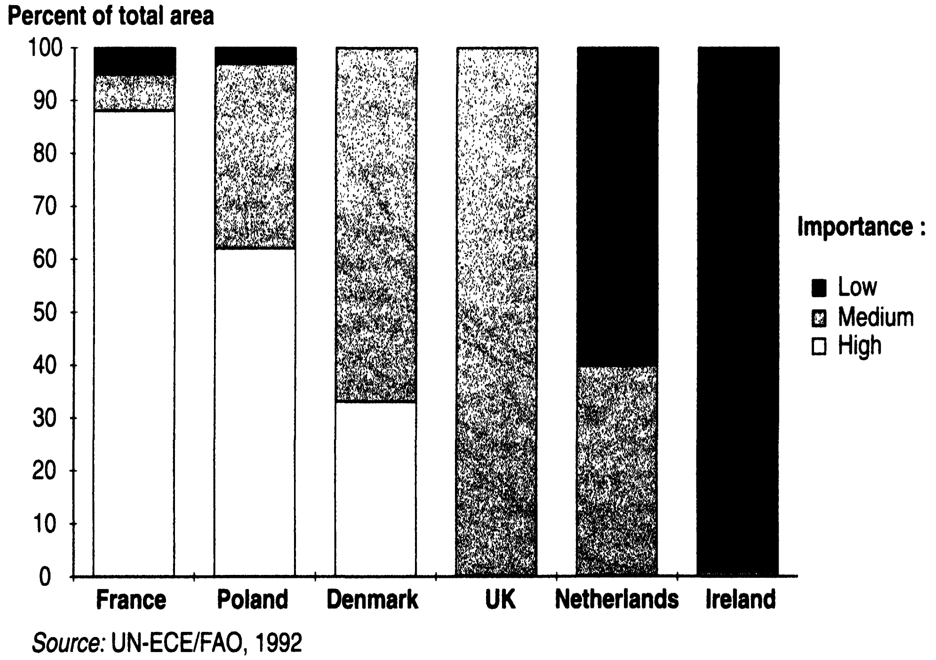
A supplementary question concerned the number and area of national parks and nature reserves and the extent to which they consisted of forest and other wooded land. In the 22 European countries providing information there were over 220 national parks with a total area of 7.7 million ha. While the size of these parks varied considerably, the average was 34 000 ha. The same 22 European countries had about 10 500 nature reserves with a total area of around 9.6 million ha or an average of 91 ha. In the former USSR 21 national parks covered 2.24 million ha, an average of 107 000 ha. The area of the United States' 339 national parks was not given, but in Australia the area of its 514 national parks was 18.6 million ha averaging 36 000 ha.

The area of forest and other wooded land in 15 European countries' national parks and nature reserves was about 2.7 million ha, corresponding to between 2 ½ and 3 percent of the total area of their forest and other wooded land. It is probable that if the same information is requested in the 2000 assessment, the areas of forest and other wooded land in national parks and nature reserves will have become noticeably higher than in the 1990 assessment as a result of policies to transfer more forest areas to such uses in many developed countries.

Forest products other than wood

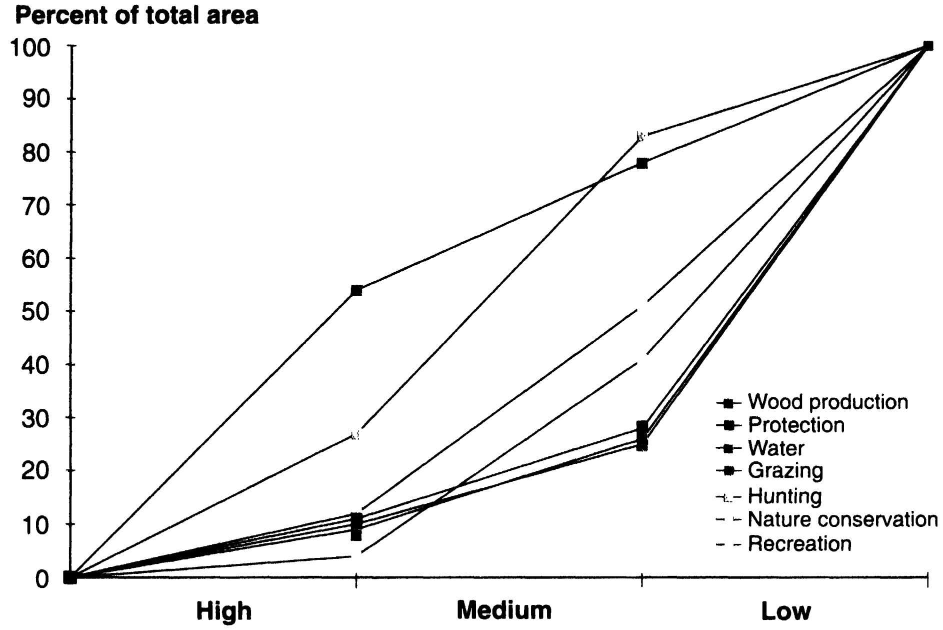
Countries were asked to list the main products of their forests and, to the extent possible, give statistics of quantities and values. Many countries provided lists of products; fewer could provide statistics either of quantity or value. The main food products, listed in terms of the number of countries naming them are: berries and nuts of different kinds; mushrooms; game meat; and honey. Of the non-wood products, the main ones reported are Christmas trees; aromatic and medicinal plants, decorative foliage (greenery); resin; and fodder. There are a number of products that are of major economic importance to individual countries or even areas within countries. The most obvious example is cork and its economic and social importance to southern Portugal.

Figure 7
Importance of hunting on public and private forest in selected countries



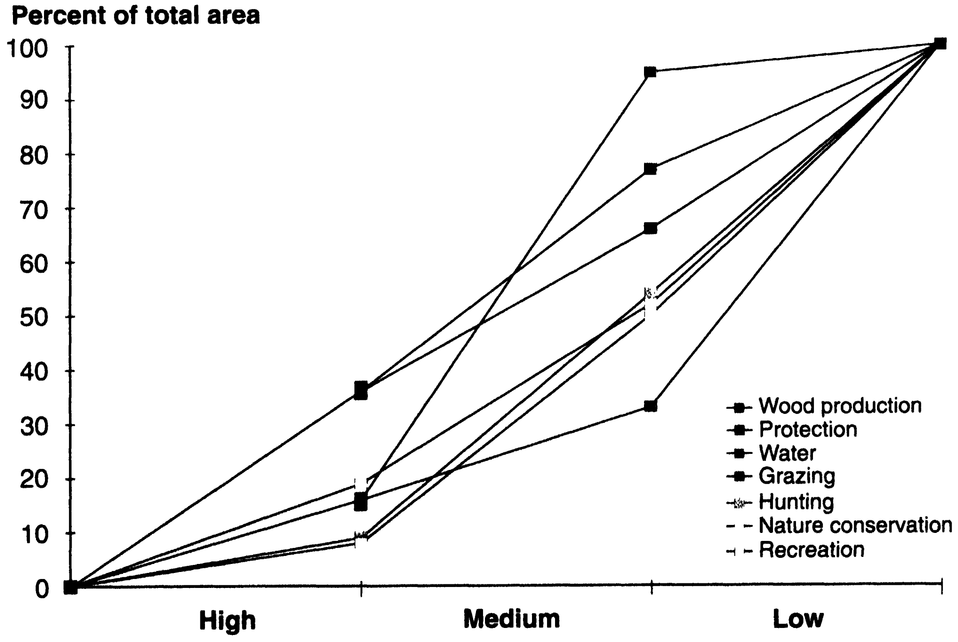
Source: UN-ECE/FAO, 1992

Figure 8
Importance of functions on public and private forest in Europe in aggregate



Source: UN-ECE/FAO, 1992

Figure 9
Importance of functions on public and private forest in the United States



Source: UN-ECE/FAO, 1992

Policy and planning activities relating to forest functions

For most of the non-wood functions of the forest, supply and demand are generally not regulated by the market mechanism. Government at various levels often has to intervene to regulate supply. Consequently, it was considered useful to find out how the emphasis in policy and planning has been changing over the past decade and whether there existed explicit plans to change the emphasis given to these functions during the 1990s. The problem with this is that it is not known how much emphasis was being given in policies to a particular function in the first place and consequently it is difficult to judge the significance of any changes that are forecast.

With this reservation in mind, it emerged that increasing emphasis has been and is expected to continue to be given to policy and planning activities relating to four functions: **protection; water; nature conservation; and recreation**.

For **grazing, hunting, and products other than wood**, more than half the replying countries expected the level of emphasis in policy making to continue at about the same levels as before. The same was true for **wood production**, although slightly more were expecting an increase in emphasis than a decrease, which might suggest that, if anything, policy toward wood production might be slightly strengthened during the 1990s. This might seem to be contrary to the evidence coming from other quarters, but on the other hand may reflect growing concern about the economic and ecological consequences of the long-term build-up of growing stock in many developed countries.

Areas of public concern and conflicts between forest functions

A change in public attitudes towards the forest and forestry sector and growing public demands on the resource have become increasingly evident over recent decades. More and more opinion-formers have expressed concern about the need to protect the environment in general and the forests, both tropical and temperate, in particular. Foresters have not always been adequately prepared for this increasing attention, and the profession has sometimes lost credibility by appearing to be slow in reacting to public concerns. Attitudes to the possible impact of air pollution on forests was a case in point.

It is an indication of how far and how fast public debate has evolved in recent years that work on the 1990 assessment of the developed countries had already been largely completed by the time of the first Ministerial Conference on the Protection of Forests in Europe in Strasbourg in December 1990 and the results published by the time of UNCED in Rio de Janeiro in June 1992. Consequently, what are today major issues such as the habitat of the spotted owl in the northwest of the United States were only just beginning to emerge (they were not mentioned in the US reply to the 1990 questionnaire), while "biological diversity" is only briefly mentioned and "sustainable forest ecosystem management" not at all in the replies to the questionnaire.

Conflicts between forest functions cover a wide field and vary considerably between one country and another. Generally speaking, however, problems most frequently arise between wood production and another function, notably environmental protection, hunting, nature conservation or recreation. This is perhaps inevitable while wood production remains the most important individual function in most countries and is the main revenue-earner. The problem may arise over the use of certain types of equipment, such as harvesters compacting the soil and damaging standing trees, harvesting systems such as clear-felling, or chemicals (pesticides, fertilisers). Other conflicts arise between nature conservation or environmental protection on the one hand and recreation on the other: damage caused to young plants by skiing, increased risk of fire in tourist areas, excess visitor numbers in sensitive ecosystems or where wildlife is disturbed, litter, and so on.

The debate continues on the extent to which forests can and should be managed on a truly multiple use basis, or whether it is better to separate uses to the extent possible, either by zoning or timing. For example, visitors may be encouraged to keep to paths and away from, for example, bird nesting sites; or silvicultural or harvesting activities may be timed to take place when the forest is not being used for other purposes, or vice versa. Another matter for discussion is the extent to which it is justified to have single-use functions, for example, wilderness areas and nature reserves, which may effectively exclude other functions.

It would be idle to pretend that the 1990 assessment could do much more than draw attention to these questions, but it probably served a useful purpose in showing policy-makers and managers in different countries that they are not alone in having to face such problems and that there may be ways and means of reconciling conflicts between functions, or at least alleviating them. In Chapter

2.3 it was pointed out that in virtually all developed countries the wood production potential is currently not being fully utilized. This is also probably true for the other functions, and a major challenge for policy-makers and managers must be to develop multiple use systems that will allow the capacity of the forest to be used more fully for a range of functions on a sustainable basis. It is to assist towards this objective that better information on the functions and uses of the forest should be collected and that improvements to the present collection methods should be sought.

Evaluation of the results of the assessment

A useful innovation in the publication of the results of the 1990 assessment for the developed countries was an analysis carried out by two outside consultants, Messrs. Koch and Linddal. This brief evaluation is partly based on the comments, but tries to go further by suggesting ways in which future assessments of the role of forests in supplying environmental and other non-wood goods and services might be further improved. Some of the main conclusions of Koch and Linddal were:

- it is hard to draw firm conclusions from the results of the assessment because of the variability in the quality and coverage of the country data;
- it is highly unlikely that it will be possible, in the near future, to make comprehensive inventories of non-wood goods and services on a global basis of the sort that have been done for wood resources. Therefore, more emphasis should be put on encouraging countries to collect data on non-wood benefits locally, rather to attempt to fashion a comprehensive information system covering the whole area;
- a major objective should be to study changes over time in the status of non-wood benefits, which would require better comparability of future assessments with the 1990 one than was achieved between those for 1980 and 1990;
- it would be desirable to reduce the pressure on just one or two individuals in their role of national correspondent to handle forest resource assessment enquiries and to encourage the formation of inter-disciplinary groups for this purpose. This would reduce the risk of misinterpretation of definitions and guidelines and the entry of bias or one-sidedness in the national replies;
- there is no need for the inclusion of new elements in future assessments. Instead, the emphasis should be on improving the quality of the information already being collected;
- forest information from Canada, the United States, the former USSR, Australia, Japan and New Zealand is not directly comparable with that for European countries, because of differences in population density, territorial size, cultural conditions and other factors;
- by trying to use a similar inventory methodology for non-wood benefits as for wood, the multiple aspects of non-wood benefits are lost. The latter should be inventoried in their own right and not in connection with their possible association with wood production.

Koch and Linddal conclude that studies of non-wood benefits are more policy analyses than economic or physical statistical exercises. The focus should be more on obtaining qualitative data that explain selected cases and less on quantitative data that probably, in the end, will not provide a useful overall picture. The fact that the data on non-wood benefits collected in the 1990 assessment may be useful only to a limited extent for evaluation and comparison between countries should not, however, force anyone to abandon attempts to collect the information, since "it is far better to be approximately right than to be precisely wrong".

Since the results of the 1990 assessment of the developed countries were published, and even before, a number of meetings have been held at which the information needs that future international forest resource assessments should supply have been discussed. These have included the IUFRO Conference on Global Natural Resource Monitoring and Assessment: Preparing for the 21st Century (Venice, 1989); the Ilvessalo Symposium on National Forest Inventories (Helsinki, 1992); the Report of the UNEP / FAO Expert Consultation on Environmental Parameters in Future Global Forest Assessment (Nairobi, 1992); and the second FAO/ECE Meeting of Experts on Global Forest Resources Assessment (Kotka, 1993). These identified a number of areas in which it would be valuable to collect information at the international level, including inventory data relevant to the question of climate change and carbon sequestration, biologica;diversity and land cover and land use, including changes.

While there is no shortage of ideas about the *contents* of future assessments, progress has been slower on developing more effective ways of *collecting* information, especially that of a qualitative kind. The tabular questionnaire approach, as used in earlier assessments, seems satisfactory for quantitative information, such as general forest inventory data, but has proved less effective for gathering information about the non-wood goods and services. If the latter are to continue to be an important part of international forest resource assessments — and there seems to be no doubt that they should be, not only for the developed countries but for the developing countries as well — there is an urgent need to find better ways of gathering information about them.

Looking again at the way in which the 1990 assessment of the developed countries was carried out, one essential change next time would seem to be to ease the burden and responsibility placed on one or two national correspondents to handle the enquiries and to reduce their isolation from the overall work on the assessment by creating much closer contacts during all phases of the assessment between them and the Rome and Geneva secretariats.

The questions in the 2000 assessment should be based on the questionnaire used for the 1990 assessment of the role of forests in supplying environmental and other non-wood goods and services. This would ensure that continuity was maintained between the 1990 and 2000 assessments. At the same time, certain aspects not sufficiently emphasized in the 1990 assessment, such as biological diversity, ecological descriptions and the quality of forests (provided an acceptable definition of "quality" can be found), should be incorporated in the 2000 assessment. Perhaps by then it will also have been possible to have made progress on the difficult problem of finding a means of placing values, expressed in comparable terms, for the different functions of the forest.

One problem with the reporting of the results of the 1990 assessment of the non-wood benefits was that of comparability between countries. The framework of questions should be designed in such a way that the answers could also be presented in some kind of a framework that would be the same for all countries, thus ensuring a degree of comparability.

Whatever system may be developed for assessing the environmental and other non-wood goods and services of the forest, it should be equally applicable to developed and developing countries, its use in the latter following on its successful trial in the former. Some adaptations might have to be made for different conditions, but the general framework should be the same.

To conclude, there appears to be general consensus on:

1) the desirability of continuing to collect information at the international level about the role of the forest in supplying environmental and other non-wood goods and services;
2) the main items of information that should be collected (though these are likely to change over time); and
3) the need to limit the information collected at the international level to no more than the essentials.

A basic need now is to develop a workable global system for the collection of information on the role of forests in supplying environmental and other non-wood goods and services and to mobilize the necessary resources to make it work. This is a matter not only for the international organizations responsible for forest resource assessments, notably FAO and UN-ECE, but also and even more so for those responsible for the carrying out of inventory activities at the national level. The forestry community has a responsibility to supply policy-makers, planners, managers and others, both within the sector and outside it, with the information they need for rational decision making, and this comprises more and more elements that cannot be obtained by traditional forest inventory methods. The challenge is to devise and put into operational new methods to gather such information.

2

SURVEY OF THE PROCESS OF DEFORESTATION AND FOREST DEGRADATION IN THE TROPICS USING HIGH RESOLUTION SATELLITE DATA

The need for detailed and reliable information on the changes in world forest resources, clearly expressed by researchers and by public opinion at large, is not being adequately met by the global statistics so far being produced. The remote sensing survey presented below was developed and implemented with the aim of producing the information needed for the tropical zone; its methodology, however, could easily be applied to the whole world.

A special publication on this important part of the 1990 assessment is in preparation. In the meantime this section is intended to give a first brief

Figure 10
Pan-tropical continuous forest resources survey design

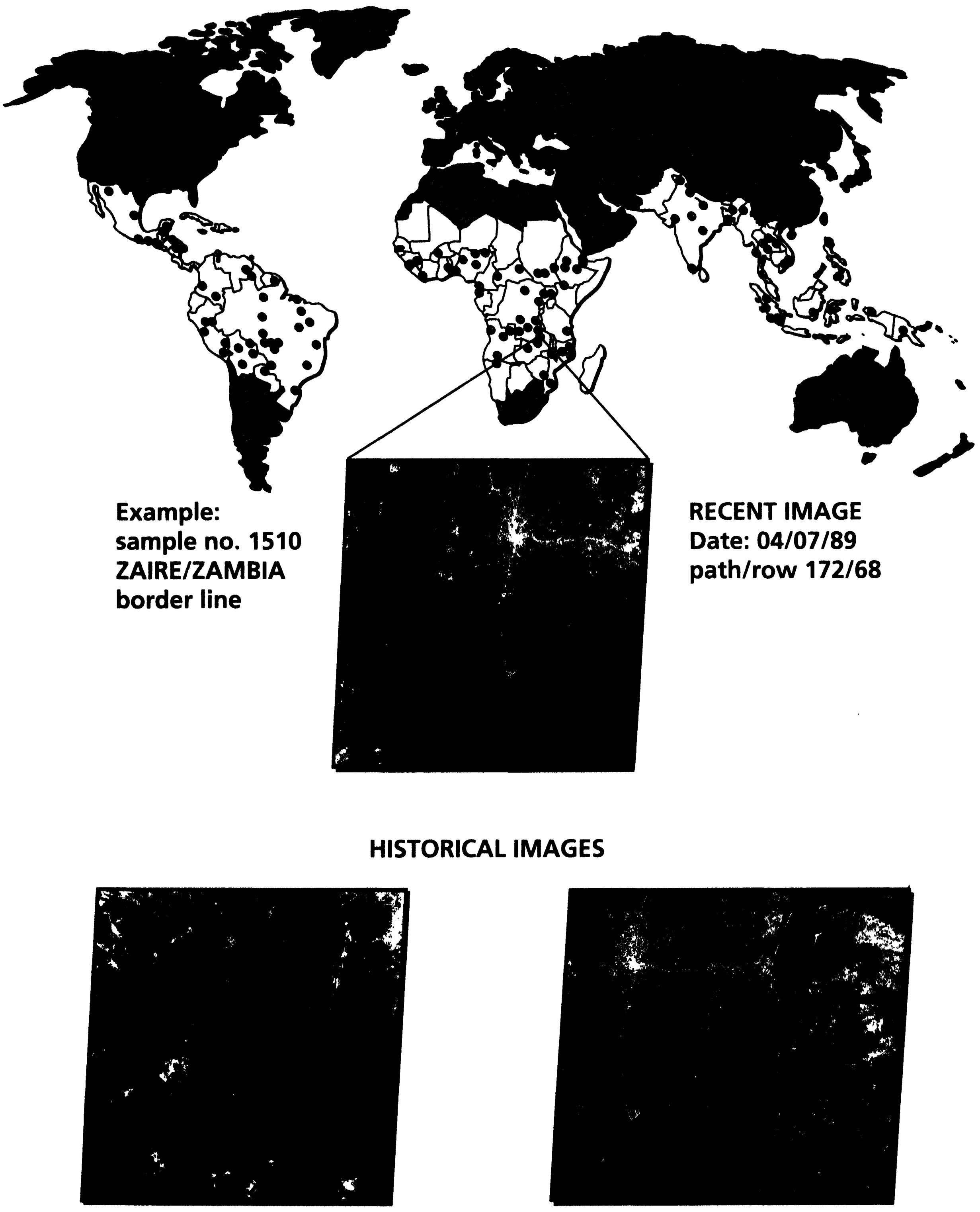
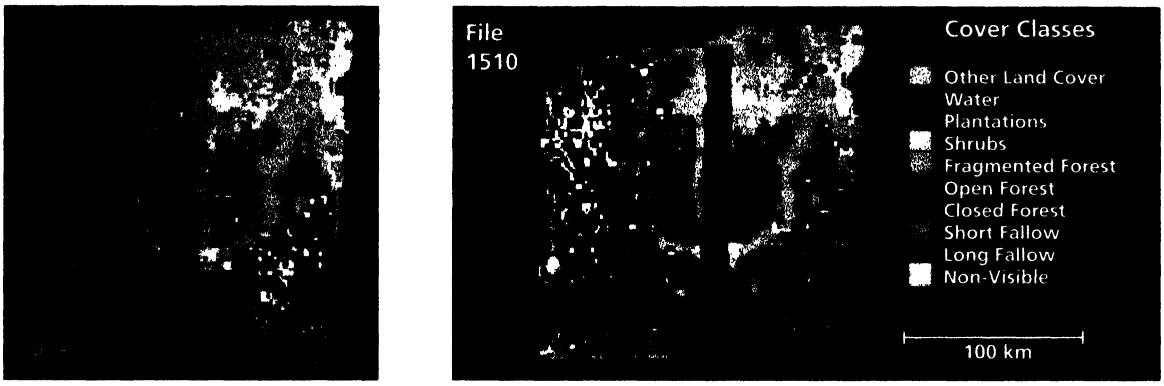


Figure 11

Example of spatial and statistical outputs, located along Zaire/Zambia border line

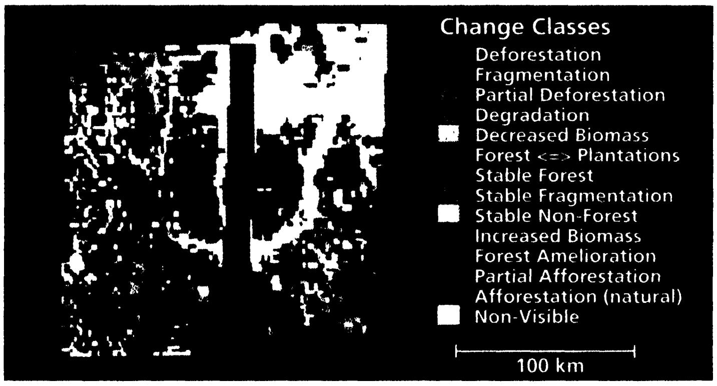
a: Maps derived from interpretation of satellite images of sample no. 1510

RECENT IMAGE **HISTORICAL IMAGES (common areas)**



04/07/1989 **13/06/81** **20/07/79**

b: Change maps produced by comparison of common areas of recent and historical images. The 100 possible class combinations (10x10) have been reduced to 14 change classes for display purposes.



changes (1981-89) changes (1979-89)

c: Sample no. 1510
– Standardized transition matrix computed for the reference period 1980– 1990

The two matrices reporting the cover class changes for periods 1981–1989 and 1980–1989 have been mathematically adjusted to the standard period 1980–1990 on the basis of transition probabilities and subsequently combined to form the comprehensive change matrix presented here.

		Cover Classes at year 1990									
Cover Classes at year 1980		Closed Forest	Open Forest	Long Fallow	Fragm. Forest	Short Fallow	Shrub	Other Land Cover	Water	Manmade Woody Veg.	Total at year 1980 '000 ha	%
Closed forest		1672.3	143.3			273.4		17.5			2106.5	71.2
Open forest		0.9	84.9			4.2		0.0			90.0	3.0
Long fallow												
Fragm. forest												
Short fallow						574.9		1.3			576.1	19.5
Shrubs												
Other land cover								160.6			160.6	5.4
Water									21.2		21.2	0.7
Manmade W.veg										2.4	2.4	0.1
Total at	'000 Ha	1673.2	228.2			852.4		179.4	21.2	2.4	2956.8	
year 1990	%	56.6	7.7			28.8		6.1	0.7	0.1		100.0

presentation of objectives, methods and main results, regarding changes in forest cover and condition over time.

OBJECTIVES

The procedure of assessment presented in annex 2 provides only estimates of forest cover and deforestation at country level. To undertake control measures or simply to diagnose the problem, a better knowledge of the change processes is essential. For this purpose, the following types of questions need to be answered:

- How are the tropical forest resources changing?
- How much is being degraded? Fragmented?
- What is happening to deforested land?
- How are forest state and change linked with ecological and socio-economic conditions?
- What are the causes of deforestation?

The only satisfactory way to provide reliable information on the process of change is to establish a forest resources monitoring system, using a globally compatible and consistent methodology. This provides reliable and location specific change information. In consideration of cost, precision and timeliness of results, a sampling approach based on remote sensing was designed and used to cover the entire tropical zone (see Figure 10). The specific objectives were:

i) to achieve the highest possible level of consistency and precision in the assessment of forest cover state and change at global and regional levels;
ii) to develop and disseminate a simple and robust monitoring technique for producing the forest cover state and change estimates at global and regional levels with application also at national level;
iii) to provide spatial and statistical data for estimating class to class changes of land cover and forest cover categories between the two dates of interpretation at the sample locations and for producing change matrices at regional and global levels.

METHODOLOGY

A distinctive feature of the methodology lies in the fact that it provides not only forest cover change data, but also maps and change matrices for each sample location. This enables estimations of class to class changes of land cover and forest categories between the two dates of interpretation at sample, regional and global levels: this is essential information for understanding the complex processes taking place, such as deforestation, fragmentation, degradation and afforestation. An example of raster maps derived from image interpretation change maps and the resulting transition matrix is given in Figure 11.

The survey is based on a sampling design covering all tropical countries. The World Reference System 2 (WRS2) for the LANDSAT satellites is used as the sampling frame. LANDSAT scenes covering approximately 3.4 million ha serve as sampling units.

In view of cost-benefit considerations, the sampling units have been selected from all LANDSAT scenes with a minimum land area of 1 million ha and a forest cover of 10% or more, estimated on the basis of existing vegetation maps. This has restricted the area surveyed to some 56% of the total tropical land area but containing over 86% of the total tropical forest.

The main characteristics of the survey design are as follows:

- It covers the entire range of woody vegetation formations in the tropics, from the rainforests of the wet zone to the shrub and tree savannas of the dry zone;
- It provides estimates of mean forest cover area and area change together with an estimate of associated error;
- It is cost-effective through use of two-stage stratification based on existing FORIS/GIS information;
- It is based on the concept of continuous forest inventory with a view to furnishing consistent estimates of mean changes over time.

This first survey round is based on a 10 per cent sample consisting of 117 sampling units randomly selected. The distribution of the selected sampling units by region is 47 in Africa, 30 in Asia and 40 in Latin America. This sample size was chosen to estimate forest cover at global level with a standard error less than ±5 per cent.

At each sample location, satellite images of the best quality and appropriate season, separated by an approximate ten-year interval, have been selected for observation. The image close to 1990 provides assessment of the current state; whereas the area in common between the "1990" and "1980" images provides the assessment to be made of the changes over time.

The salient features from a remote sensing point of view are the following:

i) **Standard classification** of various forest classes (closed, open, with shifting cultivation, fragmented) on a pan-tropical basis;

ii) **Interdependent interpretation procedure**: this interpretation approach secures the highest level of thematic and spatial consistency between historical and recent image classification. This procedure is the most important element of the methodology since it reduces the error associated to the estimate of changes and makes production of change matrices possible;

iii) **Image archive:** all images used represent permanent reference as part of a continuous time series; in future these images will be used to estimate the speed of change (3 or more time series);

iv) **Low sophistication**: in spite of its sound conceptual basis, the methods and procedures developed for this survey are simple and robust and require very low technological inputs; the methodology has been designed for implementation in average developing country conditions;

vi) **Flexibility**: although applied here in a global survey context, the monitoring methodology can be applied at national or sub-national level without substantial modifications.

LAND COVER CLASSES

Closed Forest
Open Forest
Long Fallow
(forest area affected by shifting cultivation)
Fragmented Forest
(mosaic of forest and non-forest)
Shrubs
Short Fallow
(agricultural areas with short fallow period)
Other Land Cover
(non-wooded)
Water
Plantation
(agricultural and forestry plantations)

The interpretation was implemented at selected regional and national forestry and/or remote sensing institutions, which have a good knowledge of the sample locations and are traditionally involved in forest resources assessment activities. With the two-fold objective of strengthening national capacities for forest monitoring and improving the quality of image interpretation, the Project organized three regional workshops and eight training sessions with national institutions, benefitting 27 countries and 81 participants.

The results and quality of the interpretation undertaken by local institutions were centrally reviewed and evaluated. A database was established and analyses carried out as is presented in the section following.

The project's Geographic Information System (GIS), with its multiple layers of geo-referenced information, has been an integral element of the survey both at the stage of survey design and at the stage of analysis of results.

Considering the extremely poor information available on the processes of change of the tropical forest resources, this project component could be considered an important achievement.

Main results

Transition matrices

The first and definitely most interesting result of the survey is its set of transition matrices, one for each Sampling Unit, that describe in detail the class-to-class changes for the ***land cover classes***. (See box)

The matrices associated with the sampling units can be aggregated at various levels following the standard statistical procedure. Mean transition matrices have been produced and subsequent change analysis has been carried out for the three regions and by three ecological zones (Wet and Very Moist, Moist, Dry). Table 16 shows the global transition matrix, which gives the estimated class-to-class transitions in the total land area surveyed for the period 1980-1990.

Transition matrices are very rich in information but somewhat difficult to interpret. In the matrix above rows' totals give the class areas at year 1980 while the columns' totals give the class areas at year 1990. The shaded values along the diagonal of the matrix represent the class areas that remained unchanged.

To read the changes observed in any single class e.g. closed forest, we first read its total at 1980, namely 1 367.96 million hectares, and then read along the row inside the matrix: 1 275.91 remained unchanged, 8.97 changed into open forest, 9.27 changed into long fallow, and so on.

Table 16
Pan-tropical area transition matrix for the standard period 1980-1990[1]

Classes at year 1980	**Classes at year 1990** *(million hectares)*									**Total 1980**	
	Closed Forest	**Open Forest**	**Long Fallow**	**Fragm. Forest**	**Shrub**	**Short Fallow**	**Other Land Cover**	**Water**	**Plantations**	***million ha***	**%**
Closed Forest	**1 275.91**	8.97	9.27	9.17	2.53	21.57	34.79	1.78	3.95	**1 367.96**	**44.6**
Open Forest	0.86	**283.31**	1.30	5.18	1.46	2.40	10.18	0.05	0.21	**304.94**	**9.9**
Long Fallow	1.10	0.26	**48.61**	1.08	0.79	2.35	2.27	0.05	0.01	**56.54**	**1.8**
Fragm. Forest	0.58	0.63	0.63	**159.33**	0.45	1.41	11.40	0.25	0.39	**175.06**	**5.7**
Shrubs	0.15	0.20	0.26	0.14	**152.69**	0.34	19.17	0.19	0.15	**173.30**	**5.6**
Short Fallow	0.56	0.29	0.46	0.39	0.16	**119.79**	7.30	0.19	0.17	**129.31**	**4.2**
Other Land Cover	0.71	0.70	0.26	1.35	1.94	2.03	**834.23**	1.58	0.44	**843.26**	**27.5**
Water	0.14	0.02	0.01	0.05	0.01	0.07	1.46	**0.00**[2]	0.02	**1.78**	**0.1**
Plantation	0.05	0.03	0.00	0.00	0.00	0.01	0.11	0.00	**15.68**	**15.88**	**0.5**
TOTAL 1990 ***million ha***	**1 280.06**	**294.41**	**60.81**	**176.69**	**160.03**	**149.97**	**920.91**	**4.09**	**21.03**	**3 068.01**	
%	***41.7***	***9.6***	***2.0***	***5.8***	***5.2***	***4.9***	***30.0***	***0.1***	***0.7***		***100.0***

[1] Results based on visible common area between recent and historical satellite images.

[2] Stable water (oceans, lakes, etc) has been excluded from the analysis of changes.

In order to complete the analysis concerning the class *closed forest* we should also consider what has changed into closed forest from other classes; this is done by reading down the closed forest column: of the total of 1 280.06 million hectares in 1990, 1 275.91 million hectares was already closed forest in 1980, 0.86 were open forest in 1980, 1.10 were long fallow, and so on.

Process of change

The area values reported in the table above do not communicate the impact of the observed land cover changes. The full magnitude of the changes is placed in better perspective when associated to estimates of biomass. An estimated mean biomass value for each class permits estimates of the biomass changes related to each class transition. The diagram in Figure 12 combines the values of change derived from Table 16 with this index of biomass.

Note: Only class transitions of more than 1.5 million hectares are shown in the diagram.

The Y axis, with its biomass values, order the classes by their estimated biomass per hectare.

The X axis reports the areas of class-to-class transitions, divided into positive and negative changes. The left side of the graph represents the lower-left part of the matrix, giving the positive class transitions (arrow up, increment of biomass), while the right side of the graph represents the upper-right part of the matrix, giving the negative class transitions (arrow down, loss of biomass).

Each transition is defined by the area value on the X axis and by the biomass value determined as the difference between the biomass values of the class of destination and the class of origin. By adding the biomass perspective, we are able to visualize and understand better the change processes, and even assess their environmental impact as release (or sequestration) of woody biomass related carbon.

The biomass flux diagram developed in this study is an essential tool to understand the typologies of change.

Figure 12 clearly shows the complexity of the dynamics observed. Some remarks:

- the negative changes are far more prevalent than the positive ones;
- almost all type of (negative) changes are represented;
- over 50% of all area changed come from the class closed forest;

- the most represented transition (closed forest to other land cover) implies a very large amount of biomass loss;
- most of new plantation area (agricultural and forestry) has been raised on previous closed forest area.

Interpretation of results

Concept of forest

The first four of the nine land cover classes used in this study represent the forest under various conditions: grades of density (closed and open), spatial disturbance (fragmented) and temporal disturbance (long fallow shifting cultivation).

These classes can be grouped to offer various definitions of forest, from the most strict one that includes only the class closed forest to the broadest one which includes all four classes. The concept of forest as defined in the glossary of the present report (developing countries) lies somewhere in the middle of the two extremes, including closed and open forest and part of fragmented forest. It is implicit, but not always recognised, that the definition of forest determines the definition of deforestation. Since there is no single definition of forest satisfying all purposes, and in order to highlight the relativity of the concept of forest, three class groupings have been used in the present survey and three forest cover and deforestation rates have been estimated:

F1 = Closed Forest
F2 = Closed + Open Forest + part of Fragmented Forest
F3 = Closed + Open Forest + Fragmented Forest + Long Fallow

The results for the area surveyed, based on the interpretation of the full recent image in each sampling unit and an associated estimate of change, are the following (the figures at years 1980 and 1990 represent percentages of land area, while the deforestation rate represents the areas lost in ten years as percentage of the 1980 forest cover):

Forest Definition	Estimated Forest Cover at year 1980	Estimated Forest Cover at year 1990	Estimated Deforestation rate
F1	43.8	40.6	7.42
F2	55.4	51.7	6.62
F3	57.9	54.4	6.03

Figure 12
Pan-tropical woody biomass flux diagram

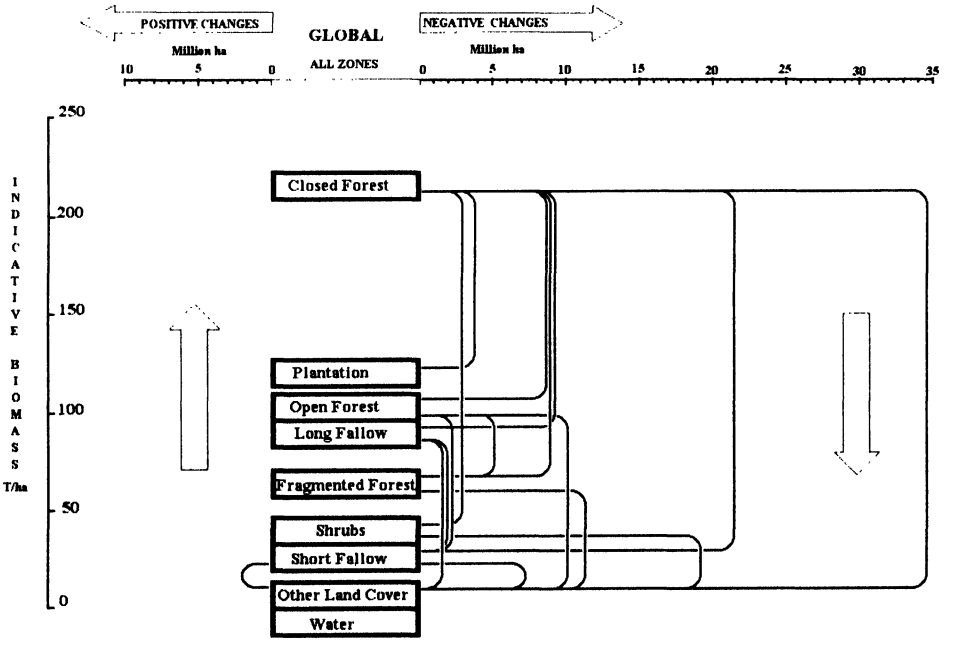
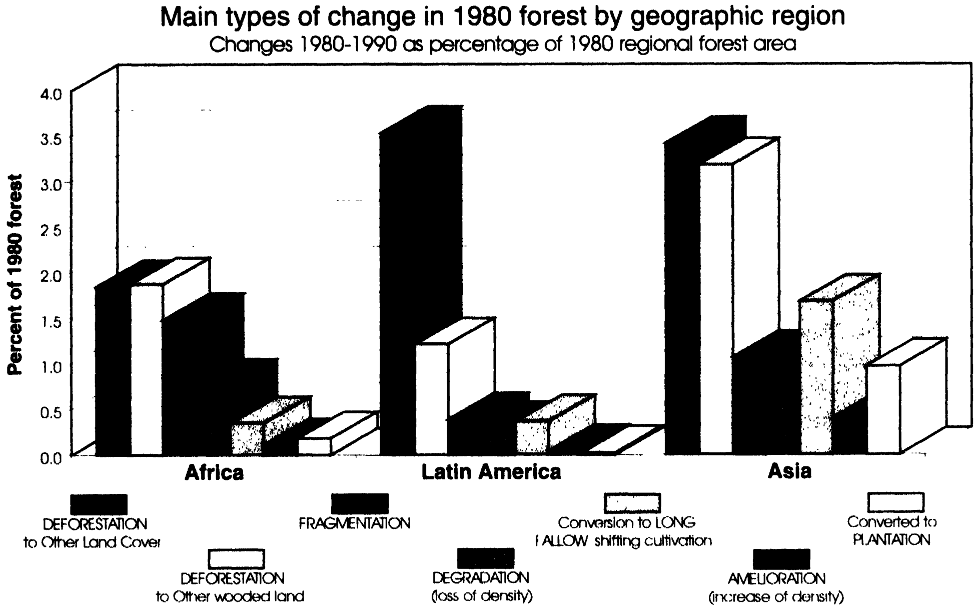


Figure 13
Forest cover changes by geographic region.



There is an apparent decrease in deforestation rate with the broadening of the forest definition. This is due to the fact that, with a broad forest concept,the negative changes within the class "forest", are considered not as deforestation, but as degradation and/or fragmentation. On the contrary, with a narrow forest concept composed by one single class, all changes from this class are necessarily considered as deforestation.

The above disscussions clearly show that for a complete accounting of biomass changes, one must adopt a classification scheme inclusive of several forest classes with varying grades of density and perturbance.

Regional characters in forest area change

The *pan-tropical* Change Matrix and the Woody Biomass Flux Diagram shown on the preceding pages summarize the land use dynamics of a wide variety of socio-economic and ecological environments. In order to evaluate the influence of these various conditions on the change processes it is useful to subdivide the pan-tropical data set into meaningful strata.

The influence of socio-economic factors on the change processes appears clearly when the results of the survey are analyzed at regional level. At that level of analysis typical change processes can be differentiated and the cause-effect relationship better understood. The graph in Figure 13 allows the regional characteristics in forest cover change to be compared.

The different patterns of forest area change indicate that there are differences between regions in the socio-economic processes causing them.

In Africa the deforestation to permanent agriculture is much less important than in the other regions and is accompanied by comparatively large amounts of deforestation to other wooded land (shrubs and short fallow agriculture), fragmentation and degradation. The process of change in Africa appears to be formed by phases of progressive degradation, characterised by a variety of relatively small changes, both in area and in biomass. The main actor behind this process is rural population pressure for land (subsistence farming, pastures) and wood (fuelwood, construction material).

In Latin America the change process appears to be quite different, with the deforestation to permanent agriculture (but also to pastures and water reservoirs) being by far the most important change while the others are almost negligible. This is mainly the effect of centrally planned operations of comparatively large scale (resettlement and forest exploitation/conversion). This type is characterised by large changes both in area and in biomass. These changes are usually fuelled by financial investments and heavy mechanisation.

In Asia both types of process seem to be represented, with important deforestation and degradation processes, the latter being mainly represented by an increase in shifting cultivation area. In this region a considerable amount of forest is converted to plantations, although primarily of agricultural type.

Results by ecological zone

In order to understand these processes in an ecological context, the change matrices were aggregated by ecological zone. The zones, being defined on the basis of rainfall, are the following:

Z1 - Wet and Very Moist (rainfall > 2 000 mm)
Z2 - Moist (with short and long dry season) (rainfall 1 000-2 000 mm)
Z3 - Sub-Dry to Dry (rainfall 200-1 000 mm)

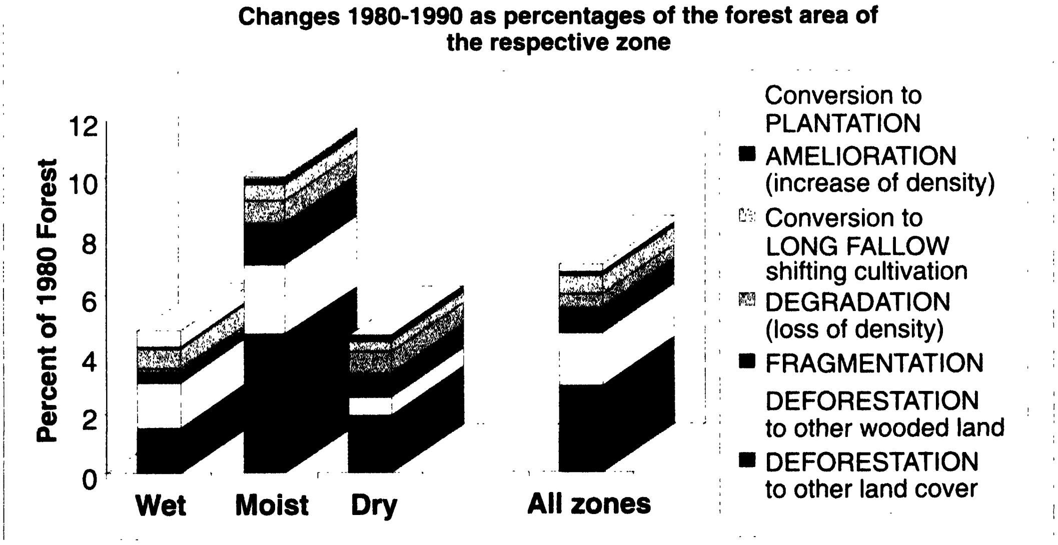
The results of this aggregation are given in Figure 14, which shows the principal types of change observed in the forest area by ecological zone. The forest definition used here corresponds to the class group (F3) composed of the classes Closed and Open Forest, Fragmented Forest and Long Fallow.

The trend is very clear (and consistent in all regions): the forest in the moist zone has been deforested, fragmented and degraded with much higher intensity than the forest in wetter and drier zones. This can be explained by the higher suitability of the moist zone to agricultural practices (and probably by the higher population density) in comparison with the other zones.

From the results so far available it appears that the socio-economic/cultural aspects determine the nature of the change process, while the ecological setting determines the intensity of change.

In addition to the analysis, the interpretations of the satellite images and the derived change maps are analyzed as spatial data and integrated with other layers of the project's Geographic Information System, such as protected areas, settlements/population density, road network, etc. with the aim of developing spatial models and a map of the risk of forest depletion. In cooperation with the EEC TREES Project the spatial data is also used in the calibration/validation of the tropical vegetation mapping and monitoring program based on coarse resolution satellite data.

Figure 14
Forest changes by ecological zone



Statistical interpretations

The pan-tropical forest cover *mean* has a *standard error* of ± 3.7% against the goal of ± 3.9%. This shows that the survey procedure and the sampling intensity were correctly chosen. The standard error of the rate of deforestation was ± 12.5%, much larger as compared to that for forest cover. This is expected because deforestation has a very high *coefficient of variation*. But even here a major gain in precision (or reduction of error) was achieved through the use of the interdependent image interpretation procedure, wherein the same person concurrently interprets the images of both the dates and estimates change directly. This resulted in much lower error, about one-fourth, compared to assessment of deforestation from independent assessments of forest cover made on two occasions by different individuals.

The survey provided estimates of forest cover at two points of time and the changes in between i.e. a trend-line. The design based on continuous forest inventory concepts is, however, well adapted for collecting reliable time-series data on forest cover, estimating changes and preparing transition matrices. The inter-dependent interpretation procedure is an essential requirement for obtaining consistent estimates of changes over a time period. The sampling makes it possible to provide results on a global basis in a timely and cost-effective manner. Two conclusions emerge from the present survey: i) the procedure of estmating forest cover changes at the global level by aggregating national statistics on changes, has unknown (large) error; and ii) the survey procedure presented here, based on sampling, is a cost-effective technique for global change assessment.

The present survey demonstrates that continuous forest inventory techniques combined with satellite images are well adapted to monitor changes in forest cover on a global scale. Such an undertaking is not an expensive proposition. Nor does it require a large institution, as the experience of the present survey indicates. Interest in global studies is now such that even a small team of 2-3 specialists could achieve such a task by mobilizing for this purpose the immense interest and resources that already exist.

CHAPTER IV

Conclusions

1

GENERAL CONCLUSIONS

While the total forest area in the developed world appears to be rather stable as a whole or even to increase slightly, the situation is fundamentally different in most of the developing regions. The population of these latter grew by about 2 billions, from 2 to 4 billions, during 1960-1990. It is expected to grow further by about 3 billions, from 4 to 7 billions, during 1990 to 2020. As a result, the risk of deforestation in the developing countries remains very high.

The current institutional capacity in most of the developing countries is not adequate to meet the present and future information needs of forestry and land use planning. The survey results indicates that in many countries even basic data related to the area and type of forests, their existing potential and volume of harvest, etc. are inadequate, if not largely lacking. The role of **information, technology and knowledge transfer** is going to be very crucial to steer the future land use changes with a minimum of economic, social and environmental costs.

The studies related to global environmental change, including global warming, deforestation and loss of biological diversity, require statistically reliable information that is consistent worldwide and over time and sufficiently adequate in detail to provide an accurate account of the complex man-forest interactions. However, the quality and quantity of available data vary considerably between countries and there are many gaps in the information supplied. As a result, the essential needs of researchers and policy makers cannot be met satisfactorily. In particular, information related to change in forest area is too generalized, incomplete and often unreliable. Therefore, there is an urgent need to establish globally accepted standards, foster national commitment and promote international cooperation in order to improve on the quality and timeliness of information gathered.

The pan-tropical sample survey demonstrates that forest and land use change information can be produced on a global basis in a cost-effective, timely and statistically sound manner. The detailed land cover classification and inter-dependent image interpretation approach provide consistent information on the change process and, thus, valuable insight on nature of *man-land* interactions. If applied on world-wide basis and continued over time, such surveys would lend factual support to global environmental research and policy making through detailed description of the processes of change and the quantification of essential parameters on a reliable basis. The approach, as may be obvious, is not intended to replace national statistics but only to provide regional and global estimates of state and change on a comparable basis over space and time.

Finally, there is need for recognition by governments and the responsible agencies that a prerequisite for effective follow-up in the field of forestry to UNCED and other high-level meetings, such as the Committee on Forestry, Ministerial Conferences for the Protection of Forests in Europe, etc. is the provision of reliable and comprehensive information on the forest resource needed for policy-making; and that such information will only become available if inventory and assessment activities are adequately funded and supported politically. With few exceptions, this is not the case at present at the national level; it is manifestly not at the international level.

2

SPECIFIC CONCLUSIONS FOR FUTURE ASSESSMENTS

The global results of the FAO and FAO/ECE Forest Resources Assessment 1990 (FRA90) have been produced from a synthesis of assessments of the developed and developing countries which use different approaches and classification systems. Core definitions are not fully identical. For these reasons the results of the assessment are not fully compatible between the developing and the developed countries. In recognition of these shortcomings there is need to serve compatibility and close coordination between the assessments of the developing and developed countries.

Global concern regarding biological diversity, global climate change and degradation of land and vegetation have raised a major interest in quantified data on these issues. The 1990 Forest Resources Assessment has produced only the beginnings of an answer to this challenge. Several expert meetings have recommended that more emphasis be given to assessment of environmental parameters. These recommendations have been endorsed by the Committee on Forestry.

A review of FAO's global assessments over the last 50 years shows that they have been carried out on occasions' separated by five to ten-year intervals. One of the major disadvantages of these occasional assessments is the loss of institutional memory, capacities and knowledge base between two successive exercises. In particular following UNCED, the fundamental importance of **continuous** forest resources assessment is now recognized (for instance by the Committee on forestry at its 1993 session) FAO intends to integrate increasingly this activity within its Regular Programme.

The availability and reliability of data from the developing countries will remain a source of major concern for future FAO global assessments. The state and change information on forest cover area and biomass could probably be made available by developing countries for regional or global purposes within the next ten or twenty years only if a concerted effort is made to enhance their capacity in forest inventory and monitoring.

For developed countries it has in most cases been possible to compile data with a detail and accuracy which exceeds that for developing countries. Data on growing stock, woody biomass, growth and harvest have been provided by the countries. Quality and quantity of data vary considerably, however, between the countries, and there are many gaps in the information supplied. Regional totals cannot be made for all variables. In a number of cases Secretariat estimates had to be made to achieve such totals. Results regarding changes in forest area are incomplete and not conclusive. Assessment of environmental parameters is advanced with regard to biomass but is only beginning for others aspects. Moreover, core definitions have been interpreted and applied quite differently in different countries due to differences in basic concepts and schools.

In view of the background described above, the following guidelines for action appear particularly important:

Country capacity building: The need for strengthening forest resources assessment activities at national and global levels has been well recognized both by governments and intergovernmental fora. The 11th Session of the Committee on Forestry held in March 1993, for example, recognised the "fundamental importance of the continuous forest resources assessment" and of "country capacity building", to provide the information for the formulation, implementation and review of the effects of plans and strategies for conservation and development of forest resources at national and international levels. For the assessment programme concerning developing countries a shift in emphasis towards the country capacity building component has been agreed. FAO could and should assist countries in preparing a long term vision of forest resources assessment as an integral part of National Forestry Action Programmes. This framework will be most useful for channelling future technical assistance and should ensure that the institutional capacity in the countries grows with time to meet future challenges in an effective manner and, in particular, generates self-reliance. Country capacity building seems the most critical issue, obviously for the countries themselves, but also for forest resources assessment. What has been said applies not only to developing countries but also to some of the countries of Central and Eastern Europe with economics in transition Therefore, it deserves the highest priority in the international cooperation in the field of forest resources assessment.

Global coordination: A better harmonization of definitions and classifications is essential. FAO should facilitate the formulation of a common framework for assessments in the developing and developed countries. An intergovernmental panel of experts in forest resource assessment and monitoring should be established to ensure that the core information is entirely comparable worldwide and that the methods of work are agreed in advance for global assessments.

Sampling approach in developed countries: In view of the uneven quality and quantity of data and the many gaps in the information supplied in the developed countries, the possibility of a common remote sensing based sampling approach similar to that successfully used in the developing countries, should be considered. Furthermore, it should be explored whether a model approach is feasible, similar to that used in the developing countries, in order to harmonize and bring to common reference years the data provided by the developed countries.

Provision of spatial data in the assessment of developed countries: The experience from the tropical forest resources assessment shows that geo-referenced data on forest cover by main type, ecological zones and population density are very useful in the study of environmental functions of forests. The need for a global coverage of such information has been expressed in a number of international meetings and conferences.

Environmental parameters: On the issues of biodiversity, biomass and land/vegetation degradation, concepts and assessment methods need to be refined. Quantitative assessment of the relevant parameters needs to be introduced in operational forest inventory work.

Integration with other databases in forestry and related sectors: To be useful, forest resource information at country, regional and global levels, must be integrated with related information in the forestry sector such as production of wood and non-wood forest products, and information outside the forestry sector such as rural and urban population, grazing intensity, energy demands, etc. Such integration can be developed most effectively within FAO.

Continuity: Collection of forest resource information should go on a continuing basis. Suitable forms should be found for dissemination at short intervals of updated information.

The institutional basis for continuous forest resource assessment programmes should be created or strengthened in host countries and in FAO at the global level.

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ANNEX 1

Country tables

These tables contain standardised country figures obtained by re-appraising the country information following the definition and classification accepted for the global assessment. This is necessary because inventory specifications generally differ from country to country. The standardisation is required to secure a consistent global picture. It is not intended to replace the original country information which remain a unique source of reference.

The thematic content of the country tables are the following:

1. Socio-economic data
2. State of forest inventory
3. Area of forest and other wooded land
4. Change in area of forest and other wooded land during 1980-90
5. Forest area, volume and biomass
6. Summary Table

Table 1 shows some important socio-economic indicators of the countries including land area, population and gross national product. The land area reported is taken from the FAO Production Yearbook. Population data were obtained from FAO Statistics Division, and GNP data from World Bank statistics.

Table 2 describes the state of forest inventory. For each country the date year of surveys/inventories used as reference is reported with a list of main inventory parameters.

Table 3 provides the area of forest and other wooded land. In case of developed countries further breakdown is provided into exploitable and unexploitable forests; and in case of developing countries into natural forests and plantations.

Table 4 relates to the changes in area of forest and other wooded land. In the case of developing countries changes in area of natural forests and plantations are also given.

Table 5 shows total forest area, volume and biomass and per hectare figures. The forest biomass presented in the table refers to Total Above Ground Biomass.

Table 6 provides a summary of main results for easy reference.

Some important notes

☐ Totals may not tally due to rounding

☐ The following abbreviations/symbols appear in Tables

n.a. : not available
( ) : figures in parenthesis are based on secretariat guesstimates
n.s. : not significant, indicating a very small value

Table 1
Socio-economic data 1990

Country	Land area	Population				G.N.P. per capita[1]	
		Total 1990	Density 1990	Annual growth 1980-1990		1990	Annual growth 1980-1990
	1 000 ha	*1 000 inh*	*inh/km²*	*1 000 inh/year*	*%*	*US$/capita*	*%*
Finland	30 462	4 990	16.4	21	0.4	24 540	2.9
Norway	30 688	4 240	13.8	17	0.4	22 830	2.5
Sweden	40 823	8 560	21.0	25	0.3	23 780	2.0
Nordics	**101 973**	**17 790**	**17.4**	**63**	**0.4**	**23 767**	**2.4**
Belgium	3 025	9 840	325.3	10	0.1	17 580	2.2
Denmark	4 253	5 140	120.9	2	n.s.	22 440	2.2
Iceland	8 844	250	2.8	3	1.1	22 090	2.4
Ireland	6 890	3 500	50.8	7	0.2	10 370	2.4
Netherlands	3 392	14 940	440.4	73	0.5	17 570	2.1
United Kingdom	24 086	57 410	238.4	114	0.2	16 080	2.8
North Western Europe	**50 490**	**91 080**	**180.4**	**207**	**0.2**	**16 642**	**2.5**
Austria	8 254	7 710	93.4	15	0.2	19 000	2.3
Former Czechoslovakia	12 540	15 660	124.9	46	0.3	3 190	0.7
France	54 325	56 440	103.9	275	0.5	19 590	2.3
Germany	34 934	79 880	228.7	79	0.1	22 360	2.3
Luxembourg	257	370	143.9	1	0.4	29 010	4.2
Poland	30 445	38 180	125.4	257	0.7	1 690	1.2
Switzerland	3 976	6 710	168.8	39	0.6	32 250	2.2
Central Eastern Europe	**144 731**	**204 950**	**141.6**	**713**	**0.4**	**16 491**	**2.2**
Albania	2 775	3 250	117.1	52	2.0	n.a.	n.a.
Bulgaria	11 019	9 010	81.8	15	0.2	2 320	1.7
Cyprus	916	700	76.4	7	1.1	8 230	6.0
Greece	12 926	10 050	77.7	39	0.4	6 010	1.6
Hungary	9 213	10 550	114.5	-21	-0.2	2 780	0.5
Israel	2 031	4 660	229.4	80	1.9	11 160	3.7
Italy	30 128	57 660	191.4	114	0.2	16 880	2.4
Romania	22 954	23 200	101.1	91	0.4	1 620	0.3
Turkey	77 079	58 690	76.1	1 194	2.3	1 640	5.4
Former Yugoslavia, SFR	25 540	23 810	93.2	237	0.7	2 940	-0.7
South East Europe	**194 581**	**201 580**	**103.6**	**2 081**	**1.1**	**6 784**	**1.8**
Portugal	8 655	10 530	121.7	61	0.6	4 950	3.2
Spain	49 937	38 960	78.0	152	0.4	11 010	3.2
Iberia	**58 592**	**49 490**	**84.5**	**214**	**0.4**	**9 721**	**3.2**
Europe	**550 367**	**564 890**	**102.6**	**3 278**	**0.6**	**12 722**	**2.2**
Belarus	20 700	10 200	49.3	57	0.6	3 110	4.0
Other Former USSR	2 060 344	288 590	14.0	3 095	0.7	3 430	2.0
Ukraine	57 955	51 700	89.2	174	0.4	2 500	2.7
Former USSR	**2 138 999**	**350 490**	**16.4**	**3 326**	**1.0**	**3 284**	**2.2**
Canada	921 500	26 520	2.9	251	1.0	20 380	3.1
USA	913 658	249 970	27.4	2 142	0.9	21 810	3.1
North America	**1 835 158**	**276 490**	**15.1**	**2 393**	**0.9**	**21 673**	**3.1**
Australia	754 402	17 090	2.3	236	1.5	16 560	2.8
Japan	36 460	123 540	338.8	601	0.5	25 840	4.3
New Zealand	26 784	3 350	12.5	26	0.8	12 570	1.0
Developed Asia/Oceania	**817 646**	**143 980**	**17.6**	**863**	**0.6**	**24 430**	**4.2**
TOTAL DEVELOPED COUNTRIES	**5 342 170**	**1 335 850**	**25.0**	**9 860**	**0.8**	**13 362**	**2.8**

Table 1
Socio-economic data 1990

Country	Land area	Population				G.N.P. per capita[1]	
		Total 1990	Density 1990	Annual growth 1980-1990		1990	Annual growth 1980-1990
	1 000 ha	*1 000 inh*	*inh/km²*	*1 000 inh/year*	*%*	*US$/capita*	*%*
AFRICA							
Burkina Faso	27 380	9 007	32.9	205	2.6	330	1.3
Cape Verde	403	379	94.0	8	2.5	680	2.2
Chad	125 920	5 679	4.5	120	2.4	180	3.8
Gambia	1 000	858	85.8	22	3.0	340	-0.1
Guinea-Bissau	2 812	950	33.8	15	1.7	180	1.3
Mali	122 019	9 362	7.7	234	2.9	200	0.1
Mauritania	102 522	2 024	2.0	47	2.7	500	-1.8
Niger	126 670	7 109	5.6	180	3.0	310	-4.1
Senegal	19 253	7 369	38.3	170	2.7	710	0.0
West Sahelian Africa	**527 979**	**42 737**	**8.1**	**1 000**	**2.7**	**352**	**-0.4**
Djibouti	2 318	427	18.4	12	3.3	n.a.	n.a.
Ethiopia, former PDR	110 100	46 744	42.5	799	1.9	120	-1.6
Kenya	56 969	25 130	44.1	850	4.2	370	0.3
Somalia	62 734	7 257	11.6	180	2.9	150	1.5
Sudan	237 600	25 195	10.6	651	3.0	400	-2.4
Uganda	19 955	18 442	92.4	532	3.5	180	3.3
East Sahelian Africa	**489 676**	**123 195**	**25.2**	**3 025**	**2.9**	**239**	**-0.5**
Benin	11 062	4 741	42.9	125	3.1	360	-1.1
Côte d'Ivoire	31 800	12 596	39.6	427	4.2	750	-3.4
Ghana	23 002	15 020	65.3	429	3.4	390	-0.3
Guinea	24 586	6 876	28.0	147	2.4	440	0.0
Liberia	9 675	2 554	26.4	70	3.2	580	0.0
Nigeria	91 077	108 949	119.6	2 400	2.5	290	-1.7
Sierra Leone	7 162	4 151	58.0	89	2.4	250	-1.3
Togo	5 439	3 455	63.5	90	3.1	410	-1.7
West Africa	**203 803**	**158 342**	**77.7**	**3 776**	**2.8**	**351**	**-1.5**
Cameroon	46 540	10 376	22.3	250	2.8	480	-1.0
Central African Republic	62 298	2 913	4.7	61	2.4	390	-1.5
Congo	34 150	1 994	5.8	47	2.7	1 000	-0.2
Equatorial Guinea	2 805	342	12.2	6	1.9	340	3.4
Gabon	25 767	1 171	4.5	37	3.8	3 550	-4.2
Zaire	226 760	35 990	15.9	961	3.2	220	-1.6
Central Africa	**398 320**	**52 786**	**13.3**	**1 362**	**3.0**	**385**	**-1.7**
Angola	124 670	10 020	8.0	230	2.6	n.a.	n.a.
Botswana	56 673	1 285	2.3	38	3.6	2 230	5.8
Burundi	2 565	5 451	212.5	135	2.9	210	1.4
Malawi	9 408	8 428	89.6	234	3.3	200	0.1
Mozambique	78 409	15 663	20.0	356	2.6	80	-3.6
Namibia	82 329	1 330	1.6	33	2.9	1 475	1.6
Rwanda	2 467	7 232	293.1	207	3.4	310	-2.6
Tanzania, United Rep.	88 604	27 328	30.8	846	3.8	110	-1.1
Zambia	74 339	8 456	11.4	272	4.0	420	-2.9
Zimbabwe	38 667	9 721	25.1	258	3.1	650	0.2
Tropical South Africa	**558 131**	**94 914**	**17.0**	**2 609**	**4.5**	**283**	**-0.4**
Comoros	223	543	243.5	16	3.6	n.a.	n.a.
Madagascar	58 154	11 980	20.6	320	3.2	230	-2.4
Mauritius	203	1 075	529.6	11	1.1	n.a.	n.a.

Table 1
Socio-economic data 1990

Country	Land area	Population				G.N.P. per capita[1]	
		Total 1990	Density 1990	Annual growth 1980-1990		1990	Annual growth 1980-1990
	1 000 ha	*1 000 inh*	*inh/km²*	*1 000 inh/year*	*%*	*US$/capita*	*%*
Reunion	250	604	241.6	10	1.8	n.a.	n.a.
Saint Helena	31	6	19.4	n.s.	1.8	n.a.	n.a.
Seychelles	27	71	263.0	1	1.4	n.a.	n.a.
Insular Africa	**58 888**	**14 279**	**24.2**	**358**	**2.9**	**230**	**-2.4**
Tropical Africa	**2 236 797**	**486 253**	**21.7**	**12 130**	**3.1**	**311**	**-1.1**
Algeria	238 174	24 960	10.5	622	2.9	2 350	1.9
Egypt	99 545	52 426	52.7	1 155	2.5	610	2.0
Libya Arab Jamahiriya	175 954	4 545	2.6	150	2.6	n.a.	n.a.
Morocco	71 085	25 061	35.3	568	2.6	970	0.4
Tunisia	15 536	8 180	52.7	180	2.5	1 440	1.2
North Africa	**600 294**	**115 172**	**19.2**	**2 675**	**2.7**	**1 146**	**1.6**
Lesotho	3 035	1 774	58.5	44	2.9	550	2.7
South Africa	122 104	38 067	31.2	847	2.5	2 530 *	n.a.
Swaziland	1 720	788	45.8	23	3.4	1 030	2.2
Non Tropical South Africa	**126 859**	**40 629**	**32.0**	**913**	**2.6**	**698**	**2.6**
Non Tropical Africa	**727 153**	**155 801**	**21.4**	**3 587**	**2.7**	**1 135**	**1.6**
TOTAL AFRICA	**2 963 950**	**642 054**	**21.7**	**15 717**	**3.0**	**470**	**0.0**
ASIA/PACIFIC							
Bangladesh	13 017	115 594	888.0	2 738	2.7	210	1.9
Bhutan	4 700	1 427	30.4	26	2.0	190	6.8
India	297 319	853 373	287.0	16 452	2.2	360	3.3
Nepal	13 680	19 143	139.9	429	2.6	180	2.1
Pakistan	77 088	122 666	159.1	3 737	3.7	400	3.2
Sri Lanka	6 463	17 209	266.3	239	1.5	470	2.5
South Asia	**412 267**	**1 129 412**	**274.0**	**23 620**	**2.4**	**347**	**3.2**
Cambodia	17 652	8 246	46.7	185	2.6	170	0.0
Laos	23 080	4 071	17.6	87	2.4	200	1.2
Myanmar	65 797	41 675	63.3	785	2.1	n.a.	n.a.
Thailand	51 089	55 702	109.0	898	1.8	1 420	5.9
Vietnam	32 549	67 171	206.4	1 347	2.3	n.a.	n.a.
Continental S. E. Asia	**190 167**	**176 865**	**93.0**	**3 302**	**2.1**	**1 195**	**5.6**
Brunei Darussalam	527	266	50.5	8	3.7	n.a.	n.a.
Indonesia	181 157	180 514	99.6	2 956	1.8	560	3.9
Malaysia	32 855	17 339	52.8	358	2.3	2 330	2.9
Philippines	29 817	62 409	209.3	1 409	2.6	730	-1.2
Singapore	61	2 712	4 445.9	30	1.2	11 088	4.8
Insular S. E. Asia	**244 417**	**263 240**	**107.7**	**4 760**	**2.0**	**826**	**2.5**
Papua New Guinea	45 286	4 011	8.9	93	2.7	850	-0.7
American Samoa	20	33	165.0	1	2.0	n.a.	n.a.
Fiji	1 827	726	39.7	9	1.4	1 780	1.5
French Polynesia	366	198	54.1	5	2.7	n.a.	n.a.
Guam	55	134	243.6	3	2.3	n.a.	n.a.
Kiribati	73	71	97.3	1	2.0	720	2.4
New Caledonia	1 828	168	9.2	3	1.8	n.a.	n.a.
Niue	26	2	7.7	n.s.	-4.0	n.a.	n.a.
Pacific Islands	178	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Table 1
Socio-economic data 1990

Country	Land area	Population				G.N.P. per capita[1]	
		Total 1990	Density 1990	Annual growth 1980-1990		1990	Annual growth 1980-1990
	1 000 ha	*1 000 inh*	*inh/km^2*	*1 000 inh/year*	*%*	*US$/capita*	*%*
Samoa	283	158	55.8	n.s.	0.2	n.a.	n.a.
Solomon Islands	2 799	320	11.4	9	3.5	590	6.7
Tonga	72	96	133.3	n.s.	0.4	1 020	2.2
Vanuatu	1 219	150	12.3	3	2.6	1 100	2.6
Pacific	**54 032**	**6 067**	**11.2**	**127**	**2.4**	**968**	**0.9**
Total Tropical Asia	**900 883**	**1 575 584**	**174.9**	**31 808**	**2.3**	**475**	**3.1**
Afghanistan	65 209	16 557	25.4	49	0.3	n.a.	n.a.
Bahrain	68	516	758.8	17	4.0	6 830 *	n.a.
Iran	163 600	54 607	33.4	1 571	3.4	2 500	2.5
Iraq	43 737	18 920	43.3	563	3.6	n.a.	n.a.
Jordan	8 893	3 282	36.9	111	4.2	1 290 *	n.a.
Kuwait	1 782	2 039	114.4	66	4.0	n.a.	n.a.
Lebanon	1 023	2 701	264.0	3	0.1	n.a.	n.a.
Oman	21 246	1 502	7.1	52	4.3	5 680	4.5
Qatar	1 100	368	33.5	14	4.9	15 876 *	-6.6
Saudi Arabia	214 969	14 134	6.6	476	4.2	7 070	-3.8
Syrian Arab Republic	18 420	12 530	68.0	373	3.6	1 000	-3.6
United Arab Emirates	8 360	1 589	19.0	57	4.6	19 870	-1.8
Yemen	52 797	11 687	22.1	347	3.6	540 *	n.a.
Middle East	**601 204**	**140 432**	**23.4**	**3 699**	**3.1**	**3 481**	**-0.4**
China	932 641	1 139 060	122.1	14 293	1.3	370	2.1
Korea, DPR	12 054	21 773	180.6	351	1.8	n.a.	n.a.
Korea, Rep.	9 902	42 793	432.2	467	1.2	5 401	12.9
Mongolia	156 650	2 190	1.4	53	1.4	n.a.	n.a.
Temperate Asia	**1 111 247**	**1 205 816**	**108.5**	**15 164**	**1.4**	**554**	**4.7**
Total Non Tropical Asia	**1 712 451**	**1 346 248**	**78.6**	**18 863**	**1.5**	**749**	**3.6**
TOTAL ASIA/PACIFIC	**2 613 334**	**2 921 832**	**111.8**	**50 671**	**1.9**	**602**	**3.3**
LATIN AMERICA/CARIBBEAN							
Costa Rica	5 106	3 015	59.0	73	2.8	1 900	1.0
El Salvador	2 085	5 252	251.9	73	1.5	1 000	-0.3
Guatemala	10 843	9 197	84.8	228	2.9	910	-1.8
Honduras	11 189	5 138	45.9	148	3.4	640	-0.7
Mexico	190 869	88 598	46.4	1 818	2.3	2 490	-0.5
Nicaragua	11 875	3 871	32.6	110	3.4	420	-4.6
Panama	7 599	2 418	31.8	46	2.1	1 900	-1.8
Central America	**239 566**	**117 489**	**49.0**	**2 496**	**2.4**	**2 123**	**-0.6**
Barbados	43	257	597.7	1	0.3	n.a.	n.a.
Bermuda	5	61	1 220.0	1	1.0	n.a.	n.a.
British Virgin Islands	15	16	106.7	n.s.	2.9	n.a.	n.a.
Cayman Islands	26	26	100.0	1	4.3	n.a.	n.a.
Monserrat	10	11	110.0	n.s.	-0.9	n.a.	n.a.
Netherlands Antilles	80	155	193.8	-2	-1.0	n.a.	n.a.
St.Pierre/Miquelon	23	6	26.1	n.s.	0.0	n.a.	n.a.
US Virgin Islands	34	107	314.7	1	0.9	n.a.	n.a.
Antigua and Barbuda	44	76	172.7	n.s.	0.1	4 290	3.8

Table 1
Socio-economic data 1990

Country	Land area	Population				G.N.P. per capita[1]	
		Total 1990	Density 1990	Annual growth 1980-1990		1990	Annual growth 1980-1990
	1 000 ha	*1 000 inh*	*inh/km²*	*1 000 inh/year*	%	*US$/capita*	%
Bahamas	1 001	260	26.0	4	1.5	11 550	1.3
Belize	2 280	182	8.0	4	2.3	1 960	2.5
Cuba	10 982	10 324	94.0	59	0.6	n.a.	n.a.
Dominica	75	82	109.3	1	1.2	2 220	4.6
Dominican Republic	4 838	7 170	148.2	147	2.3	830	-0.2
French Guyana	8 815	92	1.0	2	2.9	n.a.	n.a.
Grenada	34	85	250.0	-2	-2.3	2 130	7.1
Guadeloupe	169	340	201.2	1	0.4	n.a.	n.a.
Guyana	19 685	1 040	5.3	18	1.9	380	-4.2
Haiti	2 756	6 504	236.0	109	1.9	370	-2.4
Jamaica	1 083	2 521	232.8	35	1.5	1 500	-0.3
Martinique	106	341	321.7	2	0.5	n.a.	n.a.
Puerto Rico	886	3 480	392.8	28	0.8	6 356	1.4
St. Kitts and Nevis	36	51	141.7	n.s.	-0.2	3 540	6.0
St. Lucia	61	150	245.9	3	2.3	2 099	1.4
St. Vincent	39	116	297.4	2	1.6	1 710	4.8
Suriname	15 600	403	2.6	5	1.3	3 350	-4.5
Trinidad and Tobago	513	1 283	250.1	19	1.6	3 460	-5.2
Caribbean	**69 239**	**35 139**	**50.8**	**437**	**1.3**	**1 931**	**-0.7**
Bolivia	108 438	7 314	6.7	174	2.8	630	-2.0
Brazil	845 651	150 368	17.8	2 908	2.2	2 680	0.4
Colombia	103 870	31 819	30.6	603	2.1	1 258	1.2
Ecuador	27 684	10 782	38.9	266	2.9	953	-0.3
Paraguay	39 730	4 277	10.8	113	3.1	1 090	-0.8
Peru	128 000	22 332	17.4	504	2.6	1 100	-2.6
Venezuela	88 205	19 736	22.4	471	2.8	2 560	-1.5
Tropical South America	**1 341 578**	**246 628**	**18.4**	**5 039**	**2.3**	**2 180**	**n.s.**
Tropical Latin Am/Caribbean	**1 650 383**	**399 256**	**24.2**	**7 972**	**2.3**	**2 148**	**-0.2**
Argentina	273 669	32 322	11.8	409	1.4	2 380	1.9
Chile	74 880	13 173	17.6	203	1.7	1 940	-0.3
Uruguay	17 481	3 094	17.7	18	0.6	2 600	-0.5
Non Tropical South America	**366 030**	**48 589**	**13.3**	**629**	**1.4**	**2 275**	**1.1**
TOTAL LATIN AM/CARIBBEAN	**2 016 413**	**447 845**	**22.2**	**8 601**	**2.2**	**2 162**	**-0.1**
TOTAL DEVELOPING COUNTRIES	**7 593 697**	**4 011 731**	**52.8**	**74 989**	**2.1**	**763**	**1.8**
GRAND TOTAL	**12 935 867**	**5 347 581**	**41.3**	**84 850**	**1.8**	**4 063**	**1.9**

[1] Sub-totals and total gross national product exclude those countries for which annual growth data is not available. The values for these countries are indicated with an *.

Table 2
State of forest inventory 1990[1]

Country	Land classification			Volume / biomass	Area change
	Year(s) of inventory	Monitoring	Information obtained by	Information obtained by	Information obtained by
Finland	80-89	yes	sampling	sampling	sampling
Norway	80-86	yes	sampling	sampling	sampling
Sweden	85-89	yes	sampling	sampling	sampling
Nordics					
Belgium	80				
Denmark	79		aggregation	aggregation	aggregation
Iceland	70-85		aggregation	aggregation	aggregation
Ireland	89		aggregation	aggregation	aggregation
Netherlands	82-85	yes	sampling	sampling	sampling
United Kingdom	88-89	yes	sampling	sampling	sampling
North Western Europe					
Austria	86-90	yes	sampling	sampling	sampling
Former Czechoslovakia	88		sampling	sampling	sampling
France	76-88	yes	sampling	sampling	sampling
Germany	87-89		aggregation	aggregation	aggregation
Luxembourg	89		aggregation	aggregation	aggregation
Poland	89		sampling	sampling	sampling
Switzerland	83-85	yes	sampling	sampling	sampling
Central Eastern Europe					
Albania	90		sampling	aggregation	sampling
Bulgaria	90		sampling	sampling	n.a.
Cyprus	90	no	aggregation	aggregation	aggregation
Greece	64	no	aggregation	aggregation	aggregation
Hungary	90		aggregation	aggregation	aggregation
Israel	89-90		sampling	sampling	n.a.
Italy	88		sampling	sampling	aggregation
Romania	90		aggregation	aggregation	aggregation
Turkey	90		aggregation	aggregation	aggregation
Former Yugoslavia, SFR	87-88		aggregation	aggregation	aggregation
South East Europe					
Portugal	80-86		aggregation	aggregation	aggregation
Spain	90		sampling	sampling	sampling
Iberia					
EUROPE					
Belarus	88		sampling	sampling	sampling
Other former USSR	88		aggregation	aggregation	aggregation
Ukraine	88		sampling	sampling	sampling
FORMER USSR					
Canada	86		aggregation	aggregation	aggregation
USA	87	yes	sampling	sampling	sampling
NORTH AMERICA					
Australia	90				
Japan	85		aggregation	aggregation	aggregation
New Zealand	87-89		aggregation	aggregation	aggregation
DEVELOPED ASIA/OCEANIA					

Table 2
State of forest inventory 1990[1]

Country	Number of national forest surveys/inventories			Survey used as baseline		Change assesment
	Total	Before 1981	1981-90 (inclusive)	Reference year	Reliability class	Reliability class
Burkina Faso	1	1	0	1980	3	3
Cape Verde	1	0	1	1980-88	3	3
Chad	0	0	0	1980	3	3
Gambia	1	1	0	1980	1	3
Guinea-Bissau	1	1	0	1976	2	3
Mali	1	0	1	1988	1	3
Mauritania	1	1	0	1980	3	3
Niger	1	1	0	1977	2	3
Senegal	1	1	0	1978	2	3
West Sahelian Africa						
Djibouti	1	0	1	1985	2	3
Ethiopia, former PDR	1	1	0	1975	3	3
Kenya	1	1	0	1976	3	3
Somalia	0	0	0	1980	3	3
Sudan	1	0	1	1983	3	3
Uganda	1	1	0	1980	3	3
East Sahelian Africa						
Benin	1	1	0	1975	2	3
Côte d'Ivoire	2	1	1	1987	1	2
Ghana	1	1	0	1980-87	3	3
Guinea	1	1	0	1980-88	2	3
Liberia	1	0	1	1981	2	3
Nigeria	1	1	0	1976	2	3
Sierra Leone	1	1	0	1976	2	3
Togo	1	1	0	1975	2	3
West Africa						
Cameroon	1	1	0	1975-87	2	3
Central African Republic	1	0	1	1982	2	3
Congo	1	1	0	1967	3	3
Equatorial Guinea	1	0	1	1990	1	3
Gabon	1	1	0	1970	3	3
Zaire	1	0	1	1976-84	2	3
Central Africa						
Angola	1	1	0	1974	2	3
Botswana	1	0	1	1987	2	3
Burundi	1	1	0	1977	2	3
Malawi	1	0	1	1990	2	3
Mozambique	1	1	0	1972	2	3
Namibia	1	1	0	1980	3	3
Rwanda	2	0	2	1987	1	2
United Republic of Tanzania	1	1	0	1972-81	2	3
Zambia	1	0	1	1984	2	3
Zimbabwe	1	0	1	1985	3	3
Tropical South Africa						
Comoros	1	1	0	1980	3	3
Madagascar	1	1	0	1973-76	2	3
Mauritius	1	1	0	1980	3	3

Table 2
State of forest inventory 1990[1]

Country	Number of national forest surveys/inventories			Survey used as baseline		Change assessment
	Total	Before 1981	1981-90 (inclusive)	Reference year	Reliability class	Reliability class
Reunion	1	1	0	1980	2	3
Saint Helena	1	1	0	1980	3	3
Seychelles	1	1	0	1980	3	3
Insular Africa						
TROPICAL AFRICA						
Algeria	1	0	1	1984	2	3
Egypt	1	1	0	1980	3	3
Libya Arab Jamahiriya	1	1	0	1980	3	3
Morocco	1	0	1	1984	3	3
Tunisia	1	0	1	1990	2	3
North Africa						
Lesotho	1	0	1	1984	3	3
South Africa	1	1	0	1955	3	3
Swaziland	1	0	1	1983	2	3
Non Tropical South Africa						
NON TROPICAL AFRICA						
Bangladesh	1	0	1	1984	2	2
Bhutan	1	1	0	1978	2	3
India	3	0	3	1988	1	2
Nepal	2	2	0	1979	2	1
Pakistan	1	0	1	1990	2	3
Sri Lanka	2	1	1	1983	2	1
South Asia						
Cambodia	2	1	1	1989	1	2
Laos	2	1	1	1989	1	1
Myanmar	2	1	1	1989	2	2
Thailand	5	3	2	1987	2	1
Vietnam	2	1	1	1987	2	2
Continental S. E. Asia						
Brunei Darussalam	1	0	1	1984	2	3
Indonesia	1	0	1	1982	2	2
Malaysia	2	1	1	1982-87	1	1
Philippines	2	1	1	1988	2	1
Singapore	1	0	1	1987	2	1
Insular S. E. Asia						
Papua New Guinea	1	0	1	1990	3	3
American Samoa	1	1	0	1980	3	3
Fiji	1	1	0	1980	3	3
French Polynesia	1	1	0	1980	3	3
Guam	1	1	0	1980	3	3
Kiribati	1	1	0	1980	3	3
New Caledonia	1	1	0	1980	3	3
Niue	1	1	0	1980	3	3
Pacific Islands	1	1	0	1980	3	3
Samoa	1	1	0	1980	3	3
Solomon Islands	1	1	0	1980	3	3

Table 2
State of forest inventory 1990[1]

Country	Number of national forest surveys/inventories			Survey used as baseline		Change assesment
	Total	Before 1981	1981-90 (inclusive)	Reference year	Reliability class	Reliability class
Tonga	1	1	0	1980	3	3
Vanuatu	1	1	0	1980	3	3
Pacific						
TROPICAL ASIA						
Afghanistan	2	1	1	1968-90	2	3
Bahrain	1	1	0	1980	3	3
Iran	1	1	0	1959-80	3	3
Iraq	1	1	0	1966	3	3
Jordan	1	0	1	1990	3	3
Kuwait	1	1	0	1980	3	3
Lebanon	2	1	1	1990	1	1
Oman	1	1	0	1980	3	3
Qatar	1	1	0	1980	3	3
Saudi Arabia	1	1	0	1971	3	3
Syrian Arab Republic	1	1	0	1980	3	3
United Arab Emirates	1	1	0	1980	3	3
Yemen	1	0	1	1987	3	3
Middle East						
China	3	1	2	1988	1	2
Korea, DPR	1	1	0	1980	3	3
Korea, Rep.	4	3	1	1992	1	1
Mongolia	1	1	0	1972	3	3
Temperate Asia						
NON TROPICAL ASIA						
Costa Rica	3	1	2	1987	1	1
El Salvador	1	1	0	1975	2	3
Guatemala	2	1	1	1988	2	2
Honduras	2	1	1	1986	2	2
Mexico	1	1	0	1970-86	2	3
Nicaragua	1	1	0	1979	3	2
Panama	2	1	1	1986	1	2
Central America						
Barbados	1	1	0	1980	3	3
Bermuda	1	1	0	1980	3	3
British Virgin Islands	1	1	0	1980	3	3
Cayman Islands	1	1	0	1980	3	3
Monserrat	1	1	0	1980	3	3
Netherlands Antilles	1	1	0	1980	3	3
St.Pierre & Miquelon	1	1	0	1980	3	3
United States Virgin Islands	1	1	0	1980	3	3
Antigua and Barbuda	1	1	0	1980	2	3
Bahamas	1	0	1	1986	2	3
Belize	1	1	0	1979	2	3
Cuba	1	0	1	1990	1	3
Dominica	1	0	1	1984	2	3
Dominican Republic	1	0	1	1983	2	3
French Guyana	1	1	0	1973	2	3

Table 2
State of forest inventory 1990[1]

Country	Number of national forest surveys/inventories			Survey used as baseline		Change assesment
	Total	Before 1981	1981-90 (inclusive)	Reference year	Reliability class	Reliability class
Grenada	1	0	1	1982	2	3
Guadeloupe	1	0	1	1985	2	3
Guyana	1	1	0	1975	2	3
Haiti	2	2	0	1977	2	3
Jamaica	2	1	1	1985	2	2
Martinique	1	1	0	1974	2	3
Puerto Rico	2	1	1	1985	1	1
St. Kitts and Nevis	1	1	0	1980	2	3
St. Lucia	1	0	1	1982	2	3
St. Vincent	1	0	1	1984	2	3
Suriname	1	1	0	1970	2	3
Trinidad and Tobago	1	1	0	1980	2	3
Caribbean						
Bolivia	1	1	0	1975	2	3
Brazil	2	1	1	1981-91	2	2
Colombia	1	1	0	1980	1	3
Ecuador	1	0	1	1987	1	3
Paraguay	3	2	1	1980-85	2	2
Peru	1	1	0	1975	1	3
Venezuela	1	1	0	1977	1	3
Tropical South America						
TROPICAL LATIN AM/CARIBBEAN						
Argentina	1	0	1	1987	3	3
Chile	1	1	0	1980	3	3
Uruguay	1	1	0	1980	3	3
NON TROPICAL SOUTH AMERICA						

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[1] The term "Monitoring" is used to cover nation-wide assessment on a continuing basis.

Table 3
Area of forest and other wooded land 1990

Country	Land area *1 000 ha*	Forest & Other Wooded land *1 000 ha*	Forest *Total 1 000 ha*	 *% of land area*	 *Exploitable forest 1 000 ha*	 *Un-exploitable forest 1 000 ha*	Other Wooded Land *1 000 ha*
Finland	30 462	23 373	20 112	66	19 511	601	3 261
Norway	30 688	9 565	8 697	28	6 638	2 059	868
Sweden	40 823	28 015	24 437	60	22 048	2 389	3 578
Nordics	**101 973**	**60 953**	**53 246**	**52**	**48 197**	**5 049**	**7 707**
Belgium	3 025	620	620	20	620	0	0
Denmark	4 253	466	466	11	466	n.a.	n.a.
Iceland	8 844	123	0	0	0	0	123
Ireland	6 890	429	396	6	394	2	33
Netherlands	3 392	334	334	10	331	3	0
United Kingdom	24 086	2 380	2 207	9	2 207	n.a.	173
North Western Europe	**50 490**	**4 352**	**4 023**	**8**	**4 018**	**5**	**329**
Austria	8 254	3 877	3 877	47	3 330	547	n.a.
Former Czechoslovakia	12 540	4 491	4 491	36	4 491	n.a.	n.a.
France	54 325	14 154	13 110	24	12 460	650	1 044
Germany	34 934	10 735	10 490	30	9 852	638	245
Luxembourg	257	88	85	33	82	3	3
Poland	30 445	8 672	8 672	28	8 460	212	n.a.
Switzerland	3 976	1 186	1 130	28	1 093	37	56
Central Eastern Europe	**144 731**	**43 203**	**41 855**	**29**	**39 768**	**2 087**	**1 348**
Albania	2 775	1 449	1 046	38	910	136	403
Bulgaria	11 019	3 683	3 386	31	3 222	164	298
Cyprus	916	280	140	15	88	52	140
Greece	12 926	6 032	2 512	19	2 289	223	3 520
Hungary	9 213	1 675	1 675	18	1 324	351	n.a.
Israel	2 031	124	102	5	80	22	22
Italy	30 128	8 550	6 750	22	4 387	2 363	1 800
Romania	22 954	6 265	6 190	27	5 413	777	75
Turkey	77 079	20 199	8 856	11	6 642	2 214	11 343
Former Yugoslavia, SFR	25 540	9 454	8 371	33	7 768	603	1 083
South East Europe	**194 581**	**57 711**	**39 028**	**20**	**32 123**	**6 905**	**18 683**
Portugal	8 655	3 102	2 755	32	2 346	410	347
Spain	49 937	25 622	8 388	17	6 506	1 882	17 234
Iberia	**58 592**	**28 724**	**11 143**	**19**	**8 852**	**2 292**	**17 581**
Europe	**550 367**	**194 943**	**149 295**	**27**	**132 958**	**16 337**	**45 648**
Belarus	20 700	6 256	6 016	29	5 392	624	240
Other former USSR	2 060 344	926 035	739 729	36	402 803	336 926	186 306
Ukraine	57 955	9 239	9 213	16	5 820	3 393	26
Former USSR	**2 138 999**	**941 530**	**754 958**	**35**	**414 015**	**340 943**	**186 572**
Canada	921 500	453 300	247 164	27	112 077	135 087	206 136
USA	913 658	295 989	209 573	23	195 596	13 977	86 416
North America	**1 835 158**	**749 289**	**456 737**	**25**	**307 673**	**149 064**	**292 552**
Australia	754 402	145 613	39 837	5	17 005	22 832	105 776
Japan	36 460	24 718	24 158	66	23 829	329	560
New Zealand	26 784	7 472	7 472	28	2 060	5 412	n.a.
Developed Asia/Oceania	**817 646**	**177 803**	**71 467**	**9**	**42 894**	**28 573**	**106 336**
TOTAL DEVELOPED COUNTRIES	**5 342 170**	**2 063 565**	**1 432 457**	**27**	**897 540**	**534 917**	**631 108**

Table 3
Area of forest and other wooded land 1990

Country	Land area *1 000 ha*	Forest & Other Wooded land *1 000 ha*	Forest Total *1 000 ha*	Forest *% of land area*	Forest *Natural* *1 000 ha*	Forest *Plantation* *1 000 ha*	Other Wooded Land *1 000 ha*
AFRICA							
Burkina Faso	27 380	13 813	4 436	16	4 416	20	9 377
Cape Verde	403	78	16	4	6	10	62
Chad	125 920	32 450	11 438	9	11 434	4	21 012
Gambia	1 000	286	98	10	97	1	188
Guinea-Bissau	2 812	2 162	2 022	72	2 021	1	140
Mali	122 019	28 791	12 158	10	12 144	14	16 633
Mauritania	102 522	4 536	556	1	554	2	3 980
Niger	126 670	10 442	2 562	2	2 550	12	7 880
Senegal	19 253	13 400	7 656	40	7 544	112	5 744
West Sahelian Africa	**527 979**	**105 956**	**40 941**	**8**	**40 766**	**175**	**65 015**
Djibouti	2 318	1 320	22	1	22	0	1 298
Ethiopia, former PDR	110 100	41 991	14 354	13	14 165	189	27 637
Kenya	56 969	16 816	1 305	2	1 187	118	15 511
Somalia	62 734	15 945	758	1	754	4	15 187
Sudan	237 600	68 955	43 179	18	42 976	203	25 776
Uganda	19 955	16 023	6 366	32	6 346	20	9 657
East Sahelian Africa	**489 676**	**161 048**	**65 983**	**13**	**65 450**	**533**	**95 065**
Benin	11 062	11 497	4 961	45	4 947	14	6 536
Côte d'Ivoire	31 800	18 952	10 967	34	10 904	63	7 985
Ghana	23 002	18 013	9 608	42	9 555	53	8 405
Guinea	24 586	17 484	6 696	27	6 692	4	10 788
Liberia	9 675	6 632	4 639	48	4 633	6	1 993
Nigeria	91 077	65 654	15 785	17	15 634	151	49 869
Sierra Leone	7 162	6 969	1 895	26	1 889	6	5 074
Togo	5 439	4 566	1 370	25	1 353	17	3 196
West Africa	**203 803**	**149 764**	**55 919**	**27**	**55 607**	**312**	**93 845**
Cameroon	46 540	35 905	20 366	44	20 350	16	15 539
Central African Republic	62 298	46 754	30 568	49	30 562	6	16 185
Congo	34 150	25 285	19 902	58	19 865	37	5 383
Equatorial Guinea	2 805	2 719	1 829	65	1 826	3	890
Gabon	25 767	19 966	18 256	71	18 235	21	1 710
Zaire	226 760	166 076	113 317	50	113 275	42	52 759
Central Africa	**398 320**	**296 704**	**204 238**	**51**	**204 113**	**125**	**92 466**
Angola	124 670	77 198	23 194	19	23 074	120	54 004
Botswana	56 673	26 561	14 262	25	14 261	1	12 299
Burundi	2 565	1 314	325	13	233	92	989
Malawi	9 408	3 724	3 612	38	3 486	126	112
Mozambique	78 409	55 881	17 357	22	17 329	28	38 524
Namibia	82 329	26 296	12 569	15	12 569	0	13 727
Rwanda	2 467	946	252	10	164	88	694
United Republic of Tanzania	88 604	68 497	33 709	38	33 555	154	34 788
Zambia	74 339	60 337	32 349	44	32 301	48	27 988
Zimbabwe	38 667	26 144	8 981	23	8 897	84	17 163
Tropical South Africa	**558 131**	**346 896**	**146 609**	**26**	**145 869**	**740**	**200 287**
Comoros	223	41	11	5	11	0	30
Madagascar	58 154	23 225	15 999	28	15 782	217	7 226
Mauritius	203	44	12	6	3	9	32
Reunion	250	135	100	40	93	7	35

Table 3
Area of forest and other wooded land 1990

Country	Land area	Forest & Other Wooded land	Forest				Other Wooded Land
	1 000 ha	*1 000 ha*	*Total 1 000 ha*	*% of land area*	*Natural 1 000 ha*	*Plantation 1 000 ha*	*1 000 ha*
Saint Helena	31	9	1	3	0	1	8
Seychelles	27	4	4	13	3	1	0
Insular Africa	**58 888**	**23 457**	**16 127**	**27**	**15 892**	**235**	**7 331**
Tropical Africa	**2 236 797**	**1 083 826**	**529 818**	**24**	**527 697**	**2 121**	**554 008**
Algeria	238 174	3 945	2 039	1	1 554	485	1 906
Egypt	99 545	34	34	0	0	34	0
Libya Arab Jamahiriya	175 954	846	400	0	190	210	446
Morocco	71 085	5 744	3 864	5	3 543	321	1 880
Tunisia	15 536	569	569	4	368	201	0
North Africa	**600 294**	**11 137**	**6 905**	**1**	**5 655**	**1 250**	**4 232**
Lesotho	3 035	23	7	0	0	7	16
South Africa	122 104	41 543	8 208	7	7 243	965	33 335
Swaziland	1 720	146	146	8	74	72	0
Non Tropical South Africa	**126 859**	**41 712**	**8 361**	**7**	**7 317**	**1 044**	**33 351**
Non Tropical Africa	**727 153**	**52 850**	**15 267**	**2**	**12 972**	**2 295**	**37 583**
TOTAL AFRICA	**2 963 950**	**1 136 676**	**545 085**	**18**	**540 669**	**4 416**	**591 591**
ASIA/PACIFIC							
Bangladesh	13 017	1 472	1 004	8	769	235	468
Bhutan	4 700	3 168	2 813	60	2 809	4	355
India	297 319	82 648	64 959	22	51 729	13 230	17 689
Nepal	13 680	5 751	5 079	37	5 023	56	672
Pakistan	77 088	3 128	2 023	3	1 855	168	1 105
Sri Lanka	6 463	3 998	1 885	29	1 746	139	2 113
South Asia	**412 267**	**100 164**	**77 762**	**19**	**63 931**	**13 831**	**22 402**
Cambodia	17 652	13 724	12 170	69	12 163	7	1 554
Laos	23 080	21 436	13 177	57	13 173	4	8 259
Myanmar	65 797	49 774	29 091	44	28 856	235	20 683
Thailand	51 089	14 968	13 264	26	12 735	529	1 704
Vietnam	32 549	23 499	9 782	30	8 312	1 470	13 717
Continental S. E. Asia	**190 167**	**123 400**	**77 484**	**41**	**75 239**	**2 245**	**45 916**
Brunei Darussalam	527	458	458	87	458	0	n.a.
Indonesia	181 157	145 108	115 674	64	109 549	6 125	29 434
Malaysia	32 855	22 248	17 664	54	17 583	81	4 584
Philippines	29 817	13 640	8 034	27	7 831	203	5 606
Singapore	61	4	4	7	4	0	0
Insular S. E. Asia	**244 417**	**181 458**	**141 834**	**58**	**135 425**	**6 409**	**39 624**
Papua New Guinea	45 286	42 115	36 030	80	36 000	30	6 085
American Samoa	20	14	0	0	0	0	14
Fiji	1 827	859	853	47	775	78	6
French Polynesia	366	115	0	0	0	0	115
Guam	55	10	0	0	0	0	10
Kiribati	73	2	0	0	0	0	2
New Caledonia	1 827	1 289	710	39	701	9	579
Niue	26	6	0	0	0	0	6
Pacific Islands	178	40	0	0	0	0	40

Table 3
Area of forest and other wooded land 1990

Country	Land area *1 000 ha*	Forest & Other Wooded land *1 000 ha*	Forest				Other Wooded Land *1 000 ha*
			Total 1 000 ha	*% of land area*	*Natural 1 000 ha*	*Plantation 1 000 ha*	
Samoa	283	164	133	47	124	9	31
Solomon Islands	2 799	2 455	2 410	86	2 394	16	45
Tonga	72	8	0	0	0	0	8
Vanuatu	1 219	809	809	66	802	7	0
Pacific	**54 032**	**47 886**	**40 945**	**76**	**40 796**	**149**	**6 941**
Total Tropical Asia	**900 883**	**452 908**	**338 025**	**38**	**315 391**	**22 634**	**114 883**
Afghanistan	65 209	2 614	1 199	2	1 191	8	1 415
Bahrain	68	0	0	0	0	0	0
Iran	163 600	11 437	1 737	1	1 658	79	9 700
Iraq	43 737	192	83	0	69	14	109
Jordan	8 893	173	51	1	28	23	122
Kuwait	1 782	5	5	0	0	5	0
Lebanon	1 023	144	78	8	65	13	66
Oman	21 246	0	0	0	0	0	0
Qatar	1 100	0	0	0	0	0	0
Saudi Arabia	214 969	902	202	0	201	1	700
Syrian Arab Republic	18 420	484	245	1	118	127	239
United Arab Emirates	8 360	60	60	1	0	60	0
Yemen	52 797	1 921	9	0	9	0	1 912
Middle East	**601 204**	**17 932**	**3 669**	**1**	**3 339**	**330**	**14 263**
China	932 641	162 029	133 799	14	101 968	31 831	28 230
Korea, DPR	12 054	7 370	6 170	51	4 700	1 470	1 200
Korea, Rep.	9 902	6 291	6 291	64	6 291	0	0
Mongolia	156 650	13 741	9 406	6	9 406	0	4 335
Temperate Asia	**1 111 247**	**189 431**	**155 666**	**14**	**122 365**	**33 301**	**33 765**
Total Non Tropical Asia	**1 712 451**	**207 362**	**159 334**	**9**	**125 704**	**33 630**	**48 028**
TOTAL ASIA/PACIFIC	**2 613 334**	**660 270**	**497 359**	**19**	**441 095**	**56 264**	**162 911**
LATIN AM./CARIBBEAN							
Costa Rica	5 106	1 569	1 456	29	1 428	28	113
El Salvador	2 085	890	127	6	123	4	763
Guatemala	10 843	9 465	4 253	39	4 225	28	5 212
Honduras	11 189	6 054	4 608	41	4 605	3	1 446
Mexico	190 869	129 057	48 695	26	48 586	109	80 362
Nicaragua	11 875	7 732	6 027	51	6 013	14	1 705
Panama	7 599	3 266	3 123	41	3 117	6	143
Central America	**239 566**	**158 034**	**68 289**	**29**	**68 097**	**192**	**89 745**
Barbados	43	5	0	0	0	0	5
Bermuda	5	1	0	0	0	0	1
British Virgin Islands	15	5	3	20	3	0	2
Cayman Islands	26	6	0	0	0	0	6
Monserrat	10	4	3	25	3	0	1
Netherlands Antilles	80	7	0	0	0	0	7
St.Pierre & Miquelon	23	1	0	0	0	0	1
United States Virgin Islands	34	14	14	41	14	0	0
Antigua and Barbuda	44	26	10	23	10	0	16
Bahamas	1 001	186	186	19	186	0	0

Table 3
Area of forest and other wooded land 1990

Country	Land area	Forest & Other Wooded land	Forest				Other Wooded Land
	1 000 ha	*1 000 ha*	*Total 1 000 ha*	*% of land area*	*Natural 1 000 ha*	*Plantation 1 000 ha*	*1 000 ha*
Belize	2 280	2 117	1 998	88	1 996	2	119
Cuba	10 982	3 262	1 960	18	1 715	245	1 302
Dominica	75	50	44	59	44	0	6
Dominican Republic	4 838	1 530	1 084	22	1 077	7	446
French Guyana	8 815	8 318	7 997	91	7 997	0	321
Grenada	34	11	6	18	6	0	5
Guadeloupe	169	93	93	55	93	0	0
Guyana	19 685	18 755	18 424	94	18 416	8	331
Haiti	2 756	139	31	1	23	8	108
Jamaica	1 083	653	254	23	239	15	399
Martinique	106	71	43	41	43	0	28
Puerto Rico	886	336	324	37	321	3	12
St. Kitts and Nevis	36	24	13	36	13	0	11
St. Lucia	61	34	5	8	5	0	29
St. Vincent	39	12	11	28	11	0	1
Suriname	15 600	15 093	14 776	95	14 768	8	317
Trinidad and Tobago	513	236	168	33	155	13	68
Caribbean	**69 239**	**50 989**	**47 447**	**69**	**47 138**	**309**	**3 543**
Bolivia	108 438	57 977	49 345	46	49 317	28	8 632
Brazil	845 651	671 921	566 007	67	561 107	4 900	105 914
Colombia	103 870	63 231	54 190	52	54 064	126	9 041
Ecuador	27 684	15 576	12 007	43	11 962	45	3 569
Paraguay	39 730	19 256	12 868	32	12 859	9	6 388
Peru	128 000	84 844	68 090	53	67 906	184	16 754
Venezuela	88 205	69 436	45 943	52	45 690	253	23 493
Tropical South America	**1 341 578**	**982 242**	**808 450**	**60**	**802 905**	**5 545**	**173 792**
Tropical L. Am/Caribbean	**1 650 383**	**1 191 265**	**924 187**	**56**	**918 140**	**6 047**	**267 079**
Argentina	273 669	50 936	34 436	13	33 889	547	16 500
Chile	74 880	16 583	8 033	11	7 018	1 015	8 550
Uruguay	17 481	933	813	5	657	156	120
Non Tropical South Am.	**366 030**	**68 453**	**43 283**	**12**	**41 564**	**1 719**	**25 170**
TOTAL L. AM/CARIBBEAN	**2 016 413**	**1 259 717**	**967 469**	**48**	**959 704**	**7 765**	**292 249**
TOTAL DEVELOPING COUNTRIES	**7 593 697**	**3 056 663**	**2 009 912**	**26**	**1 941 467**	**68 445**	**1 046 751**
GRAND TOTAL	**12 935 867**	**5 120 227**	**3 442 369**	**27**			**1 677 859**

Table 4
Annual changes in forest and other wooded land area in the developed countries 1980-90

Country	Forest and other woooded land		
	Status	Annual change 1980-90 [1]	
	1 000 ha	*1 000 ha*	*%*
Finland	23 373	5.5	0.02
Norway	9 565	n.a.	n.a.
Sweden	28 015	n.s.	n.s.
Nordics	**60 953**	**5.5**	**0.02**
Belgium	620	1.9	0.31
Denmark	466	1.0	0.22
Iceland	123	n.a.	n.a.
Ireland	429	4.8	1.19
Netherlands	334	1.0	0.30
United Kingdom	2 380	24.2	1.08
North Western Europe	**4 352**	**32.9**	**0.81**
Austria	3 877	14.2	0.37
Former Czechoslovakia	4 491	2.0	0.04
France	14 154	8.0	0.06
Germany	10 735	46.9	0.45
Luxembourg	88	0.1	0.06
Poland	8 672	5.0	0.06
Switzerland	1 186	6.6	0.57
Central Eastern Europe	**43 203**	**82.8**	**0.19**
Albania	1 449	0.1	0.01
Bulgaria	3 683	7.8	0.21
Cyprus	280	0.2	0.07
Greece	6 032	0.9	0.02
Hungary	1 675	8.2	0.50
Israel	124	n.a.	n.a.
Italy	8 550	n.a.	n.a.
Romania	6 265	0.2	0.00
Turkey	20 199	3.1	0.02
Former Yugoslavia, SFR	9 454	34.5	0.37
South East Europe	**57 711**	**55.0**	**0.11**
Portugal	3 102	13.8	0.46
Spain	25 622	0.9	0.00
Iberia	**28 724**	**14.7**	**0.05**
Europe	**194 943**	**190.8**	**0.13**
Belarus	6 256	27.3	0.45
Other former USSR	926 035	n.a.	n.a.
Ukraine	9 239	24.0	0.26
Former USSR	**941 530**	**51.3**	**0.01**
Canada	453 300	n.s.	n.s.
USA	295 989	-316.5	-0.11
North America	**749 289**	**-316.5**	**-0.11**
Australia	145 613	0.6	0.00
Japan	24 718	-4.8	-0.02
New Zealand	7 472	n.a.	n.a.
Developed Asia/Oceania	**177 803**	**-4.2**	**0.00**
TOTAL DEVELOPED COUNTRIES	**2 063 565**	**-78.6**	**-0.01**

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[1] Estimates of area change are not available for the main part of the former USSR. Estimates for the former USSR in regional and world tables include only Belarus and Ukraine

Table 4
Annual changes in forest and other wooded land area in the developing countries 1980-90

Country	Forest and other woooded land			Natural forest		Plantations	
	Status	Annual change 1980-90		Status	An. change	Status	An. change
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*		*1 000 ha*	
AFRICA							
Burkina Faso	13 813			4 416	-32	20	1.1
Cape Verde	78			6	0	10	0.7
Chad	32 450			11 434	-89	4	0.2
Gambia	286			97	-1	1	n.s.
Guinea-Bissau	2 162			2 021	-16	1	n.s.
Mali	28 791			12 144	-106	14	1.3
Mauritania	4 536			554	0	2	0.2
Niger	10 442			2 550	0	12	0.8
Senegal	13 400			7 544	-52	112	10.3
West Sahelian Africa	**105 956**	**-297**	**-0.3**	**40 766**	**-295**	**175**	**14.6**
Djibouti	1 320			22	0	0	n.s.
Ethiopia, former PDR	41 991			14 165	-39	189	12.0
Kenya	16 816			1 187	-7	118	1.6
Somalia	15 945			754	-3	4	n.s.
Sudan	68 955			42 976	-482	203	8.8
Uganda	16 023			6 346	-65	20	n.s.
East Sahelian Africa	**161 048**	**-642**	**-0.4**	**65 450**	**-595**	**533**	**22.0**
Benin	11 497			4 947	-70	14	0.6
Côte d'Ivoire	18 952			10 904	-119	63	3.2
Ghana	18 013			9 555	-138	53	1.1
Guinea	17 484			6 692	-87	4	0.1
Liberia	6 632			4 633	-25	6	0.1
Nigeria	65 654			15 634	-119	151	3.7
Sierra Leone	6 969			1 889	-12	6	0.2
Togo	4 566			1 353	-22	17	1.2
West Africa	**149 764**	**-85**	**-0.1**	**55 607**	**-591**	**312**	**10.0**
Cameroon	35 905			20 350	-122	16	1.2
Central African Republic	46 753			30 562	-129	6	0.6
Congo	25 285			19 865	-32	37	2.5
Equatorial Guinea	2 719			1 826	-7	3	n.s.
Gabon	19 966			18 235	-116	21	0.8
Zaire	166 076			113 275	-732	42	2.6
Central Africa	**296 704**	**-571**	**-0.2**	**204 113**	**-1 139**	**125**	**7.7**
Angola	77 198			23 074	-174	120	1.0
Botswana	26 561			14 261	-77	1	n.s.
Burundi	1 314			233	-1	92	7.9
Malawi	3 724			3 486	-53	126	7.0
Mozambique	55 881			17 329	-135	28	1.0
Namibia	26 296			12 569	-43	0	n.s.
Rwanda	946			164	0	88	4.3
United Republic of Tanzania	68 497			33 555	-438	154	8.6
Zambia	60 337			32 301	-363	48	2.1
Zimbabwe	26 144			8 897	-61	84	1.4
Tropical South Africa	**346 896**	**-736**	**-0.2**	**145 869**	**-1 345**	**740**	**33.2**
Comoros	41			11	-1	0	n.s.
Madagascar	23 225			15 782	-135	217	3.1
Mauritius	44			3	0	9	0.1

Table 4
Annual changes in forest and other wooded land area in the developing countries 1980-90

Country	Forest and other woooded land			Natural forest		Plantations	
	Status	Annual change 1980-90		Status	An. change	Status	An. change
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*		*1 000 ha*	
Reunion	135			93	0	7	0.1
Saint Helena	9			0	0	1	n.s.
Seychelles	4			3	0	1	n.s.
Insular Africa	**23 457**	**-89**	**-0.4**	**15 892**	**-135**	**235**	**3.4**
Tropical Africa	**1 083 826**	**-2 421**	**-0.2**	**527 697**	**-4 101**	**2 121**	**90.9**
Algeria	3 945			1 554	-38	485	18.3
Egypt	34			0	0	34	0.6
Libya Arab Jamahiriya	846			190	0	210	11.0
Morocco	5 744			3 543	-26	321	9.6
Tunisia	569			368	-6	201	11.2
North Africa	**11 137**	**-73**	**-1.2**	**5 655**	**-71**	**1 250**	**50.7**
Lesotho	23			0	0	7	0.6
South Africa	41 543			7 243	-63	965	15.5
Swaziland	146			74	0	72	0.1
Non Tropical South Africa	**41 712**	**-333**	**-0.8**	**7 317**	**-63**	**1 044**	**16.1**
Non Tropical Africa	**52 850**	**-407**	**-0.9**	**12 972**	**-134**	**2 295**	**66.8**
TOTAL AFRICA	**1 136 676**	**-2 828**	**-0.3**	**540 669**	**-4 234**	**4 416**	**157.7**
ASIA/PACIFIC							
Bangladesh	1 472			769	-38	235	12.3
Bhutan	3 168			2 809	-16	4	0.2
India	82 648			51 729	-339	13 230	1 009.0
Nepal	5 751			5 023	-54	56	4.3
Pakistan	3 128			1 855	-77	168	4.2
Sri Lanka	3 998			1 746	-27	139	6.0
South Asia	**100 164**	**596**	**-0.5**	**63 931**	**-551**	**13 831**	**1 035.9**
Cambodia	13 724			12 163	-131	7	n.s.
Laos	21 436			13 173	-129	4	0.1
Myanmar	49 774			28 856	-401	235	19.6
Thailand	14 968			12 735	-515	529	29.4
Vietnam	23 499			8 312	-137	1 470	49.0
Continental S. E. Asia	**123 400**	**-1 087**	**-0.9**	**75 239**	**-1 314**	**2 245**	**98.1**
Brunei Darussalam	458			458	-2	0	n.s.
Indonesia	145 108			109 549	-1 212	6 125	331.8
Malaysia	22 248			17 583	-396	81	6.3
Philippines	13 640			7 831	-316	203	n.s.
Singapore	4			4	0	0	n.s.
Insular S. E. Asia	**181 458**	**-1 509**	**-1.0**	**135 425**	**-1 926**	**6 409**	**337.4**
Papua New Guinea	42 115			36 000	-113	30	1.5
American Samoa	14			0	0	0	n.s.
Fiji	859			775	-4	78	5.0
French Polynesia	115			0	0	0	n.s.
Guam	10			0	0	0	n.s.
Kiribati	2			0	0	0	n.s.
New Caledonia	1 289			701	-1	9	0.4
Niue	6			0	0	0	n.s.

Table 4
Annual changes in forest and other wooded land area in the developing countries 1980-90

Country	Forest and other woooded land			Natural forest		Plantations	
	Status	Annual change 1980-90		Status	An. change	Status	An. change
	1 000 ha	*1 000 ha*	%	*1 000 ha*		*1 000 ha*	
Pacific Islands	40			0	0	0	n.s.
Samoa	164			124	-2	9	0.5
Solomon Islands	2 455			2 394	-5	16	0.3
Tonga	8			0	0	0	n.s.
Vanuatu	809			802	-8	7	0.4
Pacific	**47 886**	**-45**	**-0.1**	**40 796**	**-131**	**149**	**8.1**
Total Tropical Asia	**452 908**	**-2 045**	**-0.8**	**315 391**	**-3 922**	**22 634**	**1 479.5**
Afghanistan	2 614			1 191	0	8	n.s.
Bahrain	0			0	0	0	n.s.
Iran	11 437			1 658	-33	79	4.9
Iraq	192			69	0	14	n.s.
Jordan	173			28	-1	23	0.8
Kuwait	5			0	0	5	0.5
Lebanon	144			65	-1	13	n.s.
Oman	0			0	0	0	n.s.
Qatar	0			0	0	0	n.s.
Saudi Arabia	902			201	-5	1	n.s.
Syrian Arab Republic	484			118	-5	127	9.9
United Arab Emirates	60			0	0	60	5.9
Yemen	1 921			9	0	0	n.s.
Middle East	**17 932**	**165**	**0.8**	**3 339**	**-44**	**330**	**22.1**
China	162 029			101 968	-400	31 831	1 139.8
Korea, DPR	7 370			4 700	0	1 470	77.0
Korea, Rep.	6 291			6 291	-1	0	n.s.
Mongolia	13 741			9 406	0	0	n.s.
Temperate Asia	**189 431**	**881**	**-0.2**	**122 365**	**-401**	**33 301**	**1 216.8**
Total Non Tropical Asia	**207 362**	**1 046**	**-0.1**	**125 704**	**-445**	**33 630**	**1 238.9**
TOTAL ASIA/PACIFIC	**660 270**	**-999**	**-0.6**	**441 095**	**-4 367**	**56 264**	**2 718.4**
LATIN AMERICA/CARIBBEAN							
Costa Rica	1 569			1 428	-50	28	2.6
El Salvador	890			123	-3	4	0.3
Guatemala	9 465			4 225	-81	28	1.8
Honduras	6 054			4 605	-112	3	0.3
Mexico	129 057			48 586	-678	109	5.3
Nicaragua	7 732			6 013	-124	14	1.3
Panama	3 266			3 117	-64	6	0.4
Central America	**158 034**	**-825**	**-0.5**	**68 097**	**-1 112**	**192**	**11.9**
Barbados	5			0	0	0	n.s.
Bermuda	1			0	0	0	n.s.
British Virgin Islands	5			3	0	0	n.s.
Cayman Islands	6			0	0	0	n.s.
Monserrat	4			3	0	0	n.s.
Netherlands Antilles	7			0	0	0	n.s.
St.Pierre & Miquelon	1			0	0	0	n.s.
United States Virgin Islands	14			14	0	0	n.s.
Antigua and Barbuda	26			10	0	0	n.s.

Table 4
Annual changes in forest and other wooded land area in the developing countries 1980-90

Country	Forest and other woooded land			Natural forest		Plantations	
	Status	Annual change 1980-90		Status	An. change	Status	An. change
	1 000 ha	*1 000 ha*	%	*1 000 ha*		*1 000 ha*	
Bahamas	186			186	-4	0	n.s.
Belize	2 117			1 996	-5	2	n.s.
Cuba	3 262			1 715	-17	245	13.5
Dominica	50			44	0	0	n.s.
Dominican Republic	1 530			1 077	-35	7	0.3
French Guyana	8 318			7 997	0	0	n.s.
Grenada	11			6	0	0	n.s.
Guadeloupe	93			93	0	0	n.s.
Guyana	18 755			18 416	-18	8	0.8
Haiti	139			23	-2	8	0.8
Jamaica	653			239	-27	15	0.6
Martinique	71			43	0	0	n.s.
Puerto Rico	336			321	4	3	0.1
St. Kitts and Nevis	24			13	0	0	n.s.
St. Lucia	34			5	0	0	n.s.
St. Vincent	12			11	0	0	n.s.
Suriname	15 093			14 768	-13	8	0.2
Trinidad and Tobago	236			155	-4	13	0.1
Caribbean	**50 989**	**-49**	**-0.1**	**47 138**	**-122**	**309**	**16.4**
Bolivia	57 977			49 317	-625	28	1.0
Brazil	671 921			561 107	-3 671	4 900	195.4
Colombia	63 231			54 064	-367	126	8.9
Ecuador	15 576			11 962	-238	45	1.5
Paraguay	19 256			12 859	-403	9	0.7
Peru	84 844			67 906	-271	184	8.8
Venezuela	69 436			45 690	-599	253	16.6
Tropical South America	**982 242**	**-4 793**	**-0.5**	**802 905**	**-6 173**	**5 545**	**232.9**
Tropical Latin America/Caribbean	**1 191 265**	**-5 668**	**-0.5**	**918 140**	**-7 407**	**6 047**	**261.2**
Argentina	50 936			33 889	-214	547	4.6
Chile	16 583			7 018	-60	1 015	54.5
Uruguay	933			657	-1	156	2.0
Non Tropical South America	**68 453**	**-380**	**-0.6**	**41 564**	**-275**	**1 719**	**61.0**
TOTAL LATIN AM./CARIBBEAN	**1 259 717**	**-6 047**	**-0.5**	**959 704**	**-7 682**	**7 765**	**322.2**
TOTAL DEVELOPING COUNTRIES	**3 056 663**	**-9 874**	**-0.4**	**1 941 468**	**-16 282**	**68 445**	**3 198.3**
GRAND TOTAL	**5 120 227**	**-9 953**	**-0.2**				

Table 5
Forest area, volume and biomass 1990 in the developed countries

Country	Area	Volume		Biomass	
	1 000 ha	*m^3/ha*	*Total (million m^3)*	*tons/ha*	*Total (million tons)*
Finland	20 112	85	1 710	47	945
Norway	8 697	71	617	36	313
Sweden	24 437	107	2 615	57	1 393
Nordics	**53 246**	**93**	**4 942**	**50**	**2 651**
Belgium	620	145	90	86	53
Denmark	466	116	54	82	38
Iceland					
Ireland	396	76	30	34	13
Netherlands	334	156	52	95	32
United Kingdom	2 207	92	203	56	124
North Western Europe	**4 023**	**107**	**429**	**65**	**260**
Austria	3 877	257	996	125	485
Former Czechoslovakia	4 491	221	993	147	660
France	13 110	136	1 783	93	1 219
Germany	10 490	266	2 790	151	1 584
Luxembourg	85	150	13	89	8
Poland	8 672	165	1 431	108	937
Switzerland	1 130	329	372	176	199
Central Eastern Europe	**41 855**	**200**	**8 378**	**122**	**5 091**
Albania	1 046	79	83	46	48
Bulgaria	3 386	118	400	61	207
Cyprus	140	33	5	31	4
Greece	2 512	63	158	34	85
Hungary	1 675	172	288	111	186
Israel	102	36	4	54	6
Italy	6 750	110	743	81	547
Romania	6 190	212	1 312	110	681
Turkey	8 856	86	762	63	558
Former Yugoslavia, SFR	8 371	132	1 105	103	862
South East Europe	**39 028**	**124**	**4 858**	**82**	**3 184**
Portugal	2 755	68	187	45	124
Spain	8 388	56	470	66	554
Iberia	**11 143**	**59**	**657**	**61**	**678**
Europe	**149 295**	**129**	**19 264**	**79**	**11 864**
Belarus	6 016	134	806	83	499
Other former USSR	739 729	111	82 110	68	50 302
Ukraine	9 213	143	1 317	92	848
Former USSR	**754 958**	**112**	**84 234**	**68**	**51 648**
Canada	247 164	116	28 671	103	25 458
USA	209 573	118	24 730	93	19 490
North America	**456 737**	**117**	**53 401**	**98**	**44 948**
Australia	39 837	83	3 306	61	2 430
Japan	24 158	118	2 851	62	1 498
New Zealand	7 472	53	396	28	209
Developed Asia/Oceania	**71 467**	**92**	**6 553**	**58**	**4 137**
TOTAL DEVELOPED COUNTRIES	**1 432 457**	**114**	**163 451**	**79**	**112 598**

Table 5
Forest area, volume and biomass 1990 in the developing countries

Country	Area	Volume		Biomass	
	1 000 ha	*m^3/ha*	*Total (million m^3)*	*tons/ha*	*Total (million tons)*
AFRICA					
Burkina Faso	4 416	38	167.8	79	349.2
Cape Verde	6	(71)	0.4	150	1.0
Chad	11 434	30	343.0	63	717.6
Gambia	97	48	4.7	100	9.6
Guinea-Bissau	2 021	36	72.8	83	167.0
Mali	12 144	30	364.3	62	749.5
Mauritania	554	30	16.6	63	35.0
Niger	2 550	14	35.7	32	82.3
Senegal	7 544	35	264.0	69	517.2
West Sahelian Africa	**40 766**	**31**	**1 269.3**	**64**	**2 628.3**
Djibouti	22	18	0.4	(40)	1.9
Ethiopia, former PDR	14 165	69	977.4	144	2 038.6
Kenya	1 187	65	77.2	95	112.7
Somalia	754	50	37.7	102	76.6
Sudan	42 976	32	1 375.2	62	2 647.9
Uganda	6 346	40	253.8	59	376.6
East Sahelian Africa	**65 450**	**42**	**2 721.7**	**80**	**5 254.2**
Benin	4 947	22	108.8	40	198.1
Côte d'Ivoire	10 904	190	2 071.8	80	870.2
Ghana	9 555	50	477.8	86	817.0
Guinea	6 692	51	341.3	84	559.1
Liberia	4 633	152	704.2	227	1 049.5
Nigeria	15 634	64	1 000.6	103	1 615.8
Sierra Leone	1 889	59	111.5	106	200.2
Togo	1 353	45	60.9	73	99.1
West Africa	**55 607**	**88**	**4 876.8**	**97**	**5 408.9**
Cameroon	20 350	190	3 866.5	145	2 951.4
Central African Republic	30 562	101	3 086.8	125	3 808.8
Congo	19 865	234	4 648.4	275	5 466.4
Equatorial Guinea	1 826	205	374.3	263	480.3
Gabon	18 235	234	4 267.0	281	5 118.5
Zaire	113 275	204	23 108.1	252	28 523.2
Central Africa	**204 113**	**193**	**39 351.1**	**227**	**46 348.6**
Angola	23 074	37	853.7	70	1 624.9
Botswana	14 261	(20)	287.4	38	546.2
Burundi	233	36	8.4	69	16.1
Malawi	3 486	75	261.5	139	485.7
Mozambique	17 329	37	641.2	80	1 383.8
Namibia	12 569	(20)	253.3	38	481.4
Rwanda	164	90	14.8	164	26.9
United Republic of Tanzania	33 555	64	2 147.5	43	1 445.3
Zambia	32 301	25	807.5	70	2 273.2
Zimbabwe	8 897	31	275.8	61	540.2
Tropical South Africa	**145 869**	**38**	**5 551.0**	**60**	**8 823.6**
Comoros	11	94	1.0	174	16.4
Madagascar	15 782	58	915.4	107	1 680.3
Mauritius	3	(95)	0.3	(170)	0.5
Reunion	93	115	10.7	193	22.2
Saint Helena	0		0.0		0.0

Table 5
Forest area, volume and biomass 1990 in the developing countries

Country	Area	Volume		Biomass	
	1 000 ha	*m^3/ha*	*Total (million m^3)*	*tons/ha*	*Total (million tons)*
Seychelles	3	100	0.3	180	18.0
Insular Africa	**15 892**	**58**	**927.6**	**109**	**1 737.4**
Tropical Africa	**527 697**	**104**	**54 697.5**	**133**	**70 201.1**
Algeria	1 554	40	62.2	127	197.4
Egypt	0		0.0		0.0
Libya Arab Jamahiriya	190	(27)	5.0	(70)	13.3
Morocco	3 543	45	159.4	122	432.2
Tunisia	368	37	13.6	75	27.6
North Africa	**5 655**	**42**	**240.3**	**119**	**670.5**
Lesotho	0		0.0		0.0
South Africa	7 243	(99)	713.4	197	1 426.9
Swaziland	74	(50)	3.7	(100)	7.4
Non Tropical South Africa	**7 317**	**98**	**717.1**	**196**	**1 434.3**
Non tropical Africa	**12 972**	**74**	**957.4**	**162**	**2 104.8**
TOTAL AFRICA	**540 669**	**103**	**55 654.9**	**134**	**72 305.8**
ASIA/PACIFIC					
Bangladesh	769	77	59.2	136	104.2
Bhutan	2 809	150	421.4	181	508.1
India	51 729	47	2 431.3	93	4 805.7
Nepal	5 023	55	276.3	109	548.7
Pakistan	1 855	87	161.4	110	203.2
Sri Lanka	1 746	45	78.6	113	197.7
South Asia	**63 931**	**54**	**3 428.0**	**100**	**6 367.6**
Cambodia	12 163	122	1 483.9	178	2 162.9
Laos	13 173	128	1 686.1	193	2 544.1
Myanmar	28 856	145	4 184.1	217	6 258.9
Thailand	12 735	62	789.6	125	1 585.3
Vietnam	8 312	119	989.1	183	1 523.6
Continental S. E. Asia	**75 239**	**121**	**9 132.8**	**187**	**14 074.8**
Brunei Darussalam	458	272	124.6	296	135.5
Indonesia	109 549	179	19 609.3	203	22 261.4
Malaysia	17 583	214	3 762.8	261	4 590.9
Philippines	7 831	182	1 425.2	236	1 848.4
Singapore	4	169	0.7	200	0.9
Insular S. E. Asia	**135 425**	**184**	**24 922.5**	**213**	**28 837.1**
Papua New Guinea	36 000	(168)	6 063.1	191	6 890.3
American Samoa	0		0.0		0.0
Fiji	775	(118)	91.2	206	159.7
French Polynesia	0		0.0		0.0
Guam	0		0.0		0.0
Kiribati	0		0.0		0.0
New Caledonia	701	(113)	78.9	197	138.1
Niue	0		0.0		0.0
Pacific Islands	0		0.0		0.0
Samoa	124	(126)	15.6	220	27.3
Solomon Islands	2 394	(115)	275.0	201	481.2
Tonga	0		0.0		0.0
Vanuatu	802	(123)	99.0	216	173.2

Table 5
Forest area, volume and biomass 1990 in the developing countries

Country	Area	Volume		Biomass	
	1 000 ha	*m^3/ha*	*Total (million m^3)*	*tons/ha*	*Total (million tons)*
Pacific	**40 796**	**162**	**6 622.8**	**193**	**7 869.8**
Total tropical Asia	**315 391**	**140**	**44 106.2**	**181**	**57 149.3**
Afghanistan	1 191	80	95.3	161	12.9
Bahrain	0		0.0		0.0
Iran	1 658	(80)	133.2	(200)	331.6
Iraq	69	43	3.0	119	5.1
Jordan	28	(40)	1.1	(100)	2.8
Kuwait	0		0.0		0.0
Lebanon	65	(40)	2.6	(100)	6.5
Oman	0		0.0		0.0
Qatar	0		0.0		0.0
Saudi Arabia	201	(8)	1.6	(20)	4.0
Syrian Arab Republic	118	45	5.3	121	5.4
United Arab Emirates	0		0.0		0.0
Yemen	9	(8)	0.1	(20)	0.2
Middle East	**3 339**	**73**	**242.2**	**110**	**368.5**
China	101 968	96	9 788.9	157	16 009.0
Korea, DPR	4 700	(55)	257.9	(90)	423.0
Korea, Rep.	6 291	(73)	460.3	(120)	754.9
Mongolia	9 406	(37)	344.1	(60)	564.4
Temperate Asia	**122 365**	**89**	**10 851.3**	**145**	**17 751.3**
Total non tropical Asia	**125 704**	**88**	**11 093.5**	**144**	**18 119.8**
TOTAL ASIA/PACIFIC	**441 095**	**125**	**55 199.6**	**171**	**75 269.1**
LATIN AMERICA/CARIBBEAN					
Costa Rica	1 428	103	147.1	184	261.9
El Salvador	123	42	5.2	94	11.6
Guatemala	4 225	98	414.1	172	725.5
Honduras	4 605	75	345.4	115	527.3
Mexico	48 586	38	1 846.3	65	3 173.6
Nicaragua	6 013	108	649.4	181	1 088.1
Panama	3 117	141	439.5	223	695.4
Central America	**68 097**	**56**	**3 846.8**	**95**	**6 483.4**
Barbados	0		0.0		0.0
Bermuda	0		0.0		0.0
British Virgin Islands	3	(62)	0.2	(120)	0.4
Cayman Islands	0		0.0		0.0
Monserrat	3	(62)	0.2	(120)	0.3
Netherlands Antilles	0		0.0		0.0
St.Pierre & Miquelon	0		0.0		0.0
United States Virgin Islands	14	(52)	0.7	(100)	1.4
Antigua and Barbuda	10	(62)	0.6	120	1.2
Bahamas	186	(62)	11.6	120	22.3
Belize	1 996	50	99.8	128	255.0
Cuba	1 715	48	82.3	122	209.0
Dominica	44	(62)	2.7	120	5.3
Dominican Republic	1 077	41	44.2	99	106.3
French Guyana	7 997	274	2 191.2	313	2 499.8
Grenada	6	(62)	0.4	120	0.7

Table 5
Forest area, volume and biomass 1990 in the developing countries

Country	Area	Volume		Biomass	
	1 000 ha	*m³/ha*	*Total (million m³)*	*tons/ha*	*Total (million tons)*
Guadeloupe	93	(62)	5.8	120	11.1
Guyana	18 416	176	3 241.2	248	4 571.5
Haiti	23	44	1.0	100	2.3
Jamaica	239	94	22.5	181	43.2
Martinique	43	(62)	2.7	120	5.1
Puerto Rico	321	(62)	20.0	120	38.5
St. Kitts and Nevis	13	(62)	0.8	120	1.6
St. Lucia	5	(62)	0.3	120	0.5
St. Vincent	11	(62)	0.7	120	1.3
Suriname	14 768	190	2 805.9	259	3 830.6
Trinidad and Tobago	155	123	19.1	210	32.6
Caribbean	**47 138**	**181**	**8 553.8**	**247**	**11 639.9**
Bolivia	49 317	74	3 649.5	150	7 376.2
Brazil	561 107	116	65 088.4	189	106 053.4
Colombia	54 064	111	6 001.1	195	10 514.6
Ecuador	11 962	109	1 303.9	197	2 354.6
Paraguay	12 859	27	347.2	62	795.6
Peru	67 906	156	10 593.3	236	16 013.6
Venezuela	45 690	107	4 888.8	189	8 615.4
Tropical South America	**802 905**	**114**	**91 872.2**	**189**	**151 723.4**
Tropical Latin America/Caribbean	**918 140**	**114**	**104 272.8**	**185**	**169 846.8**
Argentina	33 889	108	3 660.0	252	8 540.0
Chile	7 018	198	1 389.6	253	1 775.6
Uruguay	657	150	98.6	220	144.5
Non Tropical South America	**41 564**	**124**	**5 148.1**	**252**	**10 460.1**
TOTAL LATIN AMERICA/CARIBBEAN	**959 704**	**114**	**109 421.0**	**188**	**180 306.9**
TOTAL DEVELOPING COUNTRIES	**1 941 467**	**113**	**220 275.5**	**169**	**327 881.9**
GRAND TOTAL	**3 373 924**	**114**	**383 726.6**	**131**	**440 479.4**

Table 6
Summary 1990

Country	Forest & other wooded land			Forest				Other wooded
	Total	Annual change		Total	%	Per cap.	Biomass	Land
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*	*of land*	*ha*	*million tons*	*1 000 ha*
Finland	23 373	5.5		20 112	66	4.03	945	3 261
Norway	9 565	n.a.		8 697	28	2.05	313	868
Sweden	28 015	n.s.		24 437	60	2.85	1 393	3 578
Nordics	**60 953**	**5.5**	**0.02**	**53 246**	**52**	**2.99**	**2 651**	**7 707**
Belgium	620	1.9		620	20	0.06	53	0
Denmark	466	1.0		466	11	0.09	38	0
Iceland	123	n.a.						123
Ireland	429	4.8		396	6	0.11	13	33
Netherlands	334	1.0		334	10	0.02	32	0
United Kingdom	2 380	24.2		2 207	9	0.04	124	173
North Western Europe	**4 352**	**32.9**	**0.81**	**4 023**	**8**	**0.04**	**260**	**329**
Austria	3 877	14.2		3 877	47	0.50	485	0
Former Czechoslovakia	4 491	2.0		4 491	36	0.29	660	0
France	14 154	8.0		13 110	24	0.23	1 219	1 044
Germany	10 735	46.9		10 490	30	0.13	1 584	245
Luxembourg	88	0.1		85	33	0.23	8	3
Poland	8 672	5.0		8 672	28	0.23	937	0
Switzerland	1 186	6.6		1 130	28	0.17	199	56
Central Eastern Europe	**43 203**	**82.8**	**0.19**	**41 855**	**29**	**0.20**	**5 091**	**1 348**
Albania	1 449	0.1		1 046	38	0.32	48	403
Bulgaria	3 683	7.8		3 386	31	0.38	207	298
Cyprus	280	0.2		140	15	0.20	4	140
Greece	6 032	0.9		2 512	19	0.25	85	3 520
Hungary	1 675	8.2		1 675	18	0.16	186	0
Israel	124	n.a.		102	5	0.02	6	22
Italy	8 550	n.a.		6 750	22	0.12	547	1 800
Romania	6 265	0.2		6 190	27	0.27	681	75
Turkey	20 199	3.1		8 856	11	0.15	558	11 343
Former Yugoslavia, SFR	9 454	34.5		8 371	33	0.35	862	1 083
South East Europe	**57 711**	**55.0**	**0.11**	**39 028**	**20**	**0.19**	**3 184**	**18 683**
Portugal	3 102	13.8		2 755	32	0.26	124	347
Spain	25 622	0.9		8 388	17	0.22	554	17 234
Iberia	**28 724**	**14.7**	**0.05**	**11 143**	**19**	**0.23**	**678**	**17 581**
Europe	**194 943**	**190.8**	**0.13**	**149 295**	**27**	**0.26**	**11 864**	**45 648**
Belarus	6 256	27.3		6 016	29	0.59	499	240
Other former USSR	926 035	n.a.		739 729	36	2.56	50 302	186 306
Ukraine	9 239	24.0		9 213	16	0.18	848	26
Former USSR	**941 530**	**51.3**	**0.01**	**754 958**	**35**	**2.15**	**51 648**	**186 572**
Canada	453 300	n.s.		247 164	27	9.32	25 458	206 136
USA	295 989	-316.5		209 573	23	0.84	19 490	86 416
North America	**749 289**	**-316.5**	**-0.11**	**456 737**	**25**	**1.65**	**44 948**	**292 552**
Australia	145 613	0.6		39 837	5	2.33	2 430	105 776
Japan	24 718	-4.8		24 158	66	0.20	1 498	560
New Zealand	7 472	n.a.		7 472	28	2.23	209	0
Developed Asia/Oceania	**177 803**	**-4.2**	**0.00**	**71 467**	**9**	**0.50**	**4 137**	**106 336**
TOTAL DEVELOPED COUNTRIES	**2 063 565**	**-78.6**	**-0.01**	**1 432 457**	**27**	**1.07**	**112 598**	**631 108**

Table 6
Summary 1990

Country	Forest & other wooded land			Forest				Other wooded
	Total	Annual change		Total	%	Per cap.	Biomass	Land
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*	*of land*	*ha*	*million tons*	*1 000 ha*
AFRICA								
Burkina Faso	13 813			4 436	16	0.49	349	9 377
Cape Verde	78			16	4	0.04	1	62
Chad	32 450			11 438	9	2.01	718	21 012
Gambia	286			98	10	0.11	10	188
Guinea-Bissau	2 162			2 022	72	2.13	167	140
Mali	28 791			12 158	10	1.30	750	16 633
Mauritania	4 536			556	1	0.27	35	3 980
Niger	10 442			2 562	2	0.36	82	7 880
Senegal	13 400			7 656	40	1.04	517	5 744
West Sahelian Africa	**105 956**	**-297.2**	**-0.29**	**40 941**	**8**	**0.96**	**2 628**	**65 015**
Djibouti	1 320			22	1	0.05	2	1 298
Ethiopia, former PDR	41 991			14 354	13	0.31	2 039	27 637
Kenya	16 816			1 305	2	0.05	113	15 511
Somalia	15 945			758	1	0.10	77	15 187
Sudan	68 955			43 179	18	1.71	2 648	25 776
Uganda	16 023			6 366	32	0.35	377	9 657
East Sahelian Africa	**161 048**	**-642.2**	**-0.40**	**65 983**	**13**	**0.54**	**5 254**	**95 065**
Benin	11 497			4 961	45	1.05	198	6 536
Côte d'Ivoire	18 952			10 967	34	0.87	870	7 985
Ghana	18 013			9 608	42	0.64	817	8 405
Guinea	17 484			6 696	27	0.97	559	10 788
Liberia	6 632			4 639	48	1.82	1 049	1 993
Nigeria	65 654			15 785	17	0.14	1 616	49 869
Sierra Leone	6 969			1 895	26	0.46	200	5 074
Togo	4 566			1 370	25	0.40	99	3 196
West Africa	**149 764**	**-85.4**	**-0.06**	**55 919**	**27**	**0.35**	**5 409**	**93 845**
Cameroon	35 905			20 366	44	1.96	2 951	15 539
Central African Republic	46 753			30 568	49	10.49	3 809	16 185
Congo	25 285			19 902	58	9.98	5 466	5 383
Equatorial Guinea	2 719			1 829	65	5.35	480	890
Gabon	19 966			18 256	71	15.59	5 118	1 710
Zaire	166 076			113 317	50	3.15	28 523	52 759
Central Africa	**296 704**	**-571.2**	**-0.19**	**204 238**	**51**	**3.87**	**46 349**	**92 466**
Angola	77 198			23 194	19	2.31	1 625	54 004
Botswana	26 561			14 262	25	11.10	546	12 299
Burundi	1 314			325	13	0.06	16	989
Malawi	3 724			3 612	38	0.43	486	112
Mozambique	55 881			17 357	22	1.11	1 384	38 524
Namibia	26 296			12 569	15	9.45	481	13 727
Rwanda	946			252	10	0.03	27	694
United Republic of Tanzania	68 497			33 709	38	1.23	1 445	34 788
Zambia	60 337			32 349	44	3.83	2 273	27 988
Zimbabwe	26 144			8 981	23	0.92	540	17 163
Tropical South Africa	**346 896**	**-735.8**	**-0.22**	**146 609**	**26**	**1.54**	**8 824**	**200 287**
Comoros	41			11	5	0.02	16	30
Madagascar	23 225			15 999	28	1.34	1 680	7 226
Mauritius	44			12	6	0.01	1	32

Table 6
Summary 1990

Country	Forest & other wooded land			Forest				Other wooded
	Total	Annual change		Total	%	Per cap.	Biomass	Land
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*	*of land*	*ha*	*million tons*	*1 000 ha*
Reunion	135			100	40	0.17	22	35
Saint Helena	9			1	3	0.17	0	8
Seychelles	4			4	13	0.05	18	0
Insular Africa	**23 457**	**-89.3**	**-0.39**	**16 127**	**27**	**1.13**	**1 737**	**7 331**
Tropical Africa	**1 083 826**	**-2 421.1**	**-0.23**	**529 818**	**24**	**1.09**	**70 201**	**554 008**
Algeria	3 945			2 039	1	0.08	197	1 906
Egypt	34			34	0	0.00	0	0
Libya Arab Jamahiriya	846			400	0	0.09	13	446
Morocco	5 744			3 864	5	0.15	432	1 880
Tunisia	569			569	4	0.07	28	0
North Africa	**11 137**	**-73.1**	**-1.17**	**6 905**	**1**	**0.06**	**671**	**4 232**
Lesotho	23			7	0	0.00	0	16
South Africa	41 543			8 208	7	0.22	1 427	33 335
Swaziland	146			146	8	0.19	7	0
Non Tropical South Africa	**41 712**	**-333.5**	**-0.82**	**8 361**	**7**	**0.21**	**1 434**	**33 351**
Non tropical Africa	**52 850**	**-406.6**	**-0.89**	**15 267**	**2**	**0.10**	**2 105**	**37 583**
TOTAL AFRICA	**1 136 676**	**-2 827.7**	**-0.26**	**545 085**	**18**	**0.85**	**72 306**	**591 591**
ASIA/PACIFIC								
Bangladesh	1 472			1 004	8	0.01	104	468
Bhutan	3 168			2 813	60	1.97	508	355
India	82 648			64 959	22	0.08	4 806	17 689
Nepal	5 751			5 079	37	0.27	549	672
Pakistan	3 128			2 023	3	0.02	203	1 105
Sri Lanka	3 998			1 885	29	0.11	198	2 113
South Asia	**100 164**	**596.3**	**-0.50**	**77 762**	**19**	**0.07**	**6 368**	**22 402**
Cambodia	13 724			12 170	69	1.48	2 163	1 554
Laos	21 436			13 177	57	3.24	2 544	8 259
Myanmar	49 774			29 091	44	0.70	6 259	20 683
Thailand	14 968			13 264	26	0.24	1 585	1 704
Vietnam	23 499			9 782	30	0.15	1 524	13 717
Continental S. E. Asia	**123 400**	**-1 087.3**	**-0.93**	**77 484**	**41**	**0.44**	**14 075**	**45 916**
Brunei Darussalam	458			458	87	1.72	136	n.a.
Indonesia	145 108			115 674	64	0.64	22 261	29 434
Malaysia	22 248			17 664	54	1.02	4 591	4 584
Philippines	13 640			8 034	27	0.13	1 848	5 606
Singapore	4			4	7	0.00	1	0
Insular S. E. Asia	**181 458**	**-1 509.2**	**-1.00**	**141 834**	**58**	**0.54**	**28 837**	**39 624**
Papua New Guinea	42 115			36 030	80	8.98	6 890	6 085
American Samoa	14			0	0	0.00	0	14
Fiji	859			853	47	1.17	160	6
French Polynesia	115			0	0	0.00	0	115
Guam	10			0	0	0.00	0	10
Kiribati	2			0	0	0.00	0	2
New Caledonia	1 289			710	39	4.23	138	579
Niue	6			0	0	0.00	0	6

Table 6
Summary 1990

Country	Forest & other wooded land			Forest				Other wooded
	Total	Annual change		Total	%	Per cap.	Biomass	Land
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*	*of land*	*ha*	*million tons*	*1 000 ha*
Pacific Islands	40			0	0	0.00	0	40
Samoa	164			133	47	0.84	27	31
Solomon Islands	2 455			2 410	86	7.53	481	45
Tonga	8			0	0	0.00	0	8
Vanuatu	809			809	66	5.39	173	0
Pacific	**47 886**	**-44.7**	**-0.11**	**40 945**	**76**	**6.75**	**7 870**	**6 941**
Total tropical Asia	**452 908**	**-2 044.9**	**-0.78**	**338 025**	**38**	**0.21**	**57 149**	**114 883**
Afghanistan	2 614			1 199	2	0.07	13	1 415
Bahrain	0			0	0	0.00	0	0
Iran	11 437			1 737	1	0.03	332	9 700
Iraq	192			83	0	0.00	5	109
Jordan	173			51	1	0.02	3	122
Kuwait	5			5	0	0.00	0	0
Lebanon	144			78	8	0.03	7	66
Oman	0			0	0	0.00	0	0
Qatar	0			0	0	0.00	0	0
Saudi Arabia	902			202	0	0.01	4	700
Syrian Arab Republic	484			245	1	0.02	5	239
United Arab Emirates	60			60	1	0.04	0	0
Yemen	1 921			9	0	0.00	0	1 912
Middle East	**17 932**	**164.7**	**0.85**	**3 669**	**1**	**0.03**	**369**	**14 263**
China	162 029			133 799	14	0.12	16 009	28 230
Korea, DPR	7 370			6 170	51	0.28	423	1 200
Korea, Rep.	6 291			6 291	64	0.15	755	0
Mongolia	13 741			9 406	6	4.29	564	4 335
Temperate Asia	**189 431**	**881.0**	**-0.21**	**155 666**	**14**	**0.13**	**17 751**	**33 765**
Total non tropical Asia	**207 362**	**1 045.7**	**-0.11**	**159 334**	**9**	**0.12**	**18 120**	**48 028**
TOTAL ASIA/PACIFIC	**660 270**	**-999.2**	**-0.60**	**497 359**	**19**	**0.17**	**75 269**	**162 911**
LATIN AMERICA/CARIBBEAN								
Costa Rica	1 569			1 456	29	0.48	262	113
El Salvador	890			127	6	0.02	12	763
Guatemala	9 465			4 253	39	0.46	725	5 212
Honduras	6 054			4 608	41	0.90	527	1 446
Mexico	129 057			48 695	26	0.55	3 174	80 362
Nicaragua	7 732			6 027	51	1.56	1 088	1 705
Panama	3 266			3 123	41	1.29	695	143
Central America	**158 034**	**-825.5**	**-0.52**	**68 289**	**29**	**0.58**	**6 483**	**89 745**
Barbados	5			0	0	0.00	0	5
Bermuda	1			0	0	0.00	0	1
British Virgin Islands	5			3	20	0.19	0	2
Cayman Islands	6			0	0	0.00	0	6
Monserrat	4			3	25	0.23	0	1
Netherlands Antilles	7			0	0	0.00	0	7
St.Pierre & Miquelon	1			0	0	0.00	0	1
United States Virgin Islands	14			14	41	0.13	1	0
Antigua and Barbuda	26			10	23	0.13	1	16

Table 6
Summary 1990

Country	Forest & other wooded land			Forest				Other wooded
	Total	Annual change		Total	%	Per cap.	Biomass	Land
	1 000 ha	*1 000 ha*	*%*	*1 000 ha*	*of land*	*ha*	*million tons*	*1 000 ha*
Bahamas	186			186	19	0.72	22	0
Belize	2 117			1 998	88	10.98	255	119
Cuba	3 262			1 960	18	0.19	209	1 302
Dominica	50			44	59	0.54	5	6
Dominican Republic	1 530			1 084	22	0.15	106	446
French Guyana	8 318			7 997	91	86.92	2 500	321
Grenada	11			6	18	0.07	1	5
Guadeloupe	93			93	55	0.27	11	0
Guyana	18 755			18 424	94	17.72	4 571	331
Haiti	139			31	1	0.00	2	108
Jamaica	653			254	23	0.10	43	399
Martinique	71			43	41	0.13	5	28
Puerto Rico	336			324	37	0.09	38	12
St. Kitts and Nevis	24			13	36	0.25	2	11
St. Lucia	34			5	8	0.03	1	29
St. Vincent	12			11	28	0.09	1	1
Suriname	15 093			14 776	95	36.67	3 831	317
Trinidad and Tobago	236			168	33	0.13	33	68
Caribbean	**50 989**	**-48.8**	**-0.13**	**47 447**	**69**	**1.35**	**11 640**	**3 543**
Bolivia	57 977			49 345	46	6.75	7 376	8 632
Brazil	671 921			566 007	67	3.76	106 053	105 914
Colombia	63 231			54 190	52	1.70	10 515	9 041
Ecuador	15 576			12 007	43	1.11	2 355	3 569
Paraguay	19 256			12 868	32	3.01	796	6 388
Peru	84 844			68 090	53	3.05	16 014	16 754
Venezuela	69 436			45 943	52	2.33	8 615	23 493
Tropical South America	**982 242**	**-4 793.2**	**-0.50**	**808 450**	**60**	**3.28**	**151 723**	**173 792**
Tropical Latin America/Caribbean	**1 191 265**	**-5 667.5**	**-0.49**	**924 187**	**56**	**2.31**	**169 847**	**267 079**
Argentina	50 936			34 436	13	1.07	8 540	16 500
Chile	16 583			8 033	11	0.61	1 776	8 550
Uruguay	933			813	5	0.26	145	120
Non tropical South America	**68 453**	**-379.7**	**-0.64**	**43 283**	**12**	**0.89**	**10 460**	**25 170**
TOTAL LATIN AMERICA/CARIBBEAN	**1 259 717**	**-6 047.2**	**-0.50**	**967 469**	**48**	**2.16**	**180 307**	**292 249**
TOTAL DEVELOPING COUNTRIES	**3 056 663**	**-9 874.1**	**-0.43**	**2 009 912**	**26**	**0.50**	**327 882**	**1 046 751**
GRAND TOTAL	**5 120 227**	**-9 952.7**	**-0.20**	**3 442 369**	**27**	**0.64**	**440 479**	**1 677 859**

ANNEX 2

Methodology and definitions

1

METHODOLOGY OF ASSESSMENT FOR THE DEVELOPED COUNTRIES

General remarks

The coverage for the developed countries' part of the global assessment was the whole of Europe (the countries as they were before the changes that began in 1989 in central and eastern Europe), the former USSR, Canada and the United States of America, Australia, Japan and New Zealand. All these countries carry out national forest inventories on either a continuing or *ad hoc* basis. Consequently, the approach used for the collection of forest resource information for the 1990 assessment was, as for earlier assessments, to rely to the greatest possible extent on the agencies responsible for the national forest inventories. In this, as in other respects, the assessment for the developed countries was markedly different from that for the developing countries, described later.

Because each country has tended to develop its own definitions and to have its own particular information needs, however, and in order to obtain as comparable information as possible, special emphasis was placed on drawing up a common classification and set of definitions and getting countries to adapt, where necessary, their national data to conform to the internationally agreed classification and definitions. For this purpose, the classification framework and definitions in the FAO publication "Toward a common framework for world forest resources assessments" were closely followed in the preparations for the assessment.

Another important consideration was the need to collect information for the 1990 assessment that was as comparable as possible with that obtained from earlier assessments.

The system used, which was a repetition of the one successfully followed in the previous (1980) assessment, was two-pronged: (1) circulation of a questionnaire, after approval by the Joint FAO/ECE Working Party on Forest Economics and Statistics, to all countries; (2) appointment by each country of a correspondent or correspondents responsible for collecting the national data, completing the questionnaire and assisting the secretariat in checking, clarifying and supplementing the information given in the questionnaire, including where necessary making estimates or providing unofficial data when official statistics were not available. An important aspect of this work was the attachment to the statistical replies of notes explaining, where necessary, how the data had been obtained, giving an indication of its reliability, and whether and why it may not have corresponded to the classification and definitions provided with the questionnaire. The correspondents proved to be a key element in the data collection system.

The first draft of the questionnaire for the developed countries was presented for discussion at the ad hoc FAO/ECE/FINNIDA Meeting of experts on forest resource assessment, held in Kotka, Finland in October 1987 (Kotka I). It was subsequently amended in the light of the Kotka discussions, further revised by an FAO/ECE team of specialists on forest resource assessment and approved by the the Joint FAO/ECE Working Party on Forest Economics and Statistics, before being circulated to countries.

In drawing up the questionnaire, a number of basic principles were followed, including: (1) the information being requested should be of interest and relevance at the international level; (2) there had to be some compromise between what it would be interesting and useful to collect and what it was reasonable to expect countries to be able to provide; (3) the majority of countries should be able to provide most of the information requested, either as official data or as informed estimates (it was recognized that not all countries would be able to answer all the questions); (4) where data were provided which did not conform to the internationally agreed classification and definitions, accompanying notes should explain the differences.

The questionnaire consisted of two parts:

I. General forest resource information;

II. The role of the forest in providing environmental and other non-wood goods and services (non-wood benefits).

Part I was almost entirely quantitative information, so that the answers were in the form of statistics, supplemented by explanatory notes. On the other hand, Part II dealt far more with qualitative matters, the possibilities to obtain statistics on non-wood benefits being much more limited than on the wood production aspects. Answers to Part II had very often to be based on subjective judgement, and their quality was highly dependent on the expertise and experience of the correspondents.

PART I

General forest resource information

This review must, for reasons of space, be limited to the methodology applied to the collation of national information at the international level, rather than the inventory methods applied at the national level for the actual collection of data. National inventory methodologies vary in function of the extensiveness of the resource, the importance attached to the forest resource and its various uses by policy makers in individual countries and the resources available for the work. Generally speaking, much of of the information for the 1990 assessment was gathered by ground surveys using sampling methods, and often as a regular monitoring system. Some countries obtained part of their inventory information from aerial surveys or other remote sensing (satellite) systems. Certain data, such as on ownership, were taken from other sources, such as cadastral records. Where national inventory systems did not exist, a number of countries built up their countrywide database from local sources, such as management plans.

The first section of Part I concerned the *place of forest and other wooded land within the total area of land*. For this, the key definition is that of "forest and other wooded land", which occasionally proved to be not as straight-forward as it might seem. The agreed definition of "land under natural or planted stands of trees, whether productive or not, including land from which forest has been cleared but that will be reforested in the foreseeable future, and including areas occupied by roads, small cleared tracts and other small open areas within the forest which constitute an integral part of the forest" raised some questions of interpretation of terms such as "land under trees", the length of time a deforested area remained "forest" and of "foreseeable future" for reforestation.

The basic land use classification was:

TOTAL AREA — INLAND WATER
- Land area
    - *Non-forest land*
        - Agricultural land
        - Other
    - *Forest & other wooded land*
        - Forest
            - Exploitable
            - Unexploitable
        - Other wooded land

The assessment of *forest and other wooded land* was based on a kind of multi-directional matrix, so that there would be internal consistency between the different elements. Information was collected for a number of forest categories according to species groups and species, management and ownership status, age-class distribution, stocking, standing volume and growing stock, annual increment, and fellings and removals. In practice, the fullest information coverage in most countries is for the category "exploitable forest", which is not surprising, given that management tends to be concentrated on this category and that by far the largest proportion of total wood supply comes from it (90 to 95 per cent in Europe). The definition of "exploitable forest" continues to raise certain difficulties, not only with regard to comparability of the concept of exploitability between countries but also between successive international assessments. In the past, other terms have been used to cover approximately the same concept, including productive forest, forest in use and operable forest. The term "production forest" is used in annex 2, table 3, which for the developed countries has the same connotation as exploitable forest. In all cases, the sense of the term is that such forests, whether managed or not and whether being currently used on a commercial scale or not, are available for wood production, i.e. there are not legal, physical or economic limitations on their use for this purpose.

The emphasis given to information relating to exploitable forest reflects the fact that forest management was until recently principally concerned with the production of wood. It is also the case that such information is mostly quantitative and can be scientifically obtained, which is often not so for information relating to the non-wood functions. For management for wood production, it is important to have good information relating to the growing stock, increment and drain, as well as to age or size class distribution, ownership and size of holdings and management status. It would also be valuable to have other information, such as economic accessibility and quality of growing stock, but here one is moving into parameters that are either variable over time (accessibility is a function of price, which can fluctuate considerably) or are difficult to assess in other than subjective terms (what is quality?). Accordingly, such data have not been collected at the international level. Regarding economic accessibility, it may be noted that the definition of "exploitable forest and other wooded land" is "land on which there are no legal, *economic* or technical restrictions on wood production...", but no distinction is made between areas that are being exploited and those that are available for exploitation but where harvesting is not at present taking place.

Because more detailed information was not available from many developed countries, questions about *changes in forest area* had to be kept general. Countries were asked to provide data on the net change of the total area of forest and other wooded land over a recent ten-year period (if possible 1980 to 1990), the net change being the total increase due to natural regeneration and afforestation of non-forest land *minus* loss of forest and other wooded land to other uses. It would have been instructive to have more detailed change data, e.g on transfers to and from various categories of non-forest land and between the different categories of forest and other wooded land, but these were seldom available from countries. Even a reliable figure of net change of total forest and other wooded land was difficult for some to provide.

Comparison of data between one assessment and the next might be expected also to provide information on changes over time. In practice, the reliability of such data has proved to be variable, depending on whether there were changes in definitions, in countries' survey methodologies in the intervening period, or in the way in which nationally-derived data were converted into the standardized FAO format. Given the increasing demand for accurate knowledge about land use changes by different groups of information seeker, there is a clear need for improvements by developed countries in methodologies for assessing changes in forest and other wooded land. In this connection, the use of remote sensing offers considerable promise, at least for changes at an aggregrated level. Its worth has been proven for developing countries, as seen in Chapter 3.2.

The gradual shift in the use of energy away from non-renewable sources, notably fossil fuels, and towards alternative sources has increased interest in the potential availability of biomass for energy. The 1990 assessment for the developed countries collected this information on *woody biomass* in a somewhat more simplified form than in the experimental questionnaire used in the 1980 assessment. The approach suggested to countries was to derive, by the use of appropriate conversion factors, the volume and mass of above-ground forest biomass from the volume of inventoried tree biomass. Estimates could thereby be obtained for the biomass of the wood and bark components of inventoried material, and also that of other above-ground tree biomass (stems, branches, tops and other). Other conversion factors could also be used to estimate the biomass of other woody above-ground biomass (shrubs, seedlings) and of stumps and roots, and so obtain a figure for total woody biomass. This information could also be relevant for analyses on the carbon cycle and climate change and forests' potential for carbon sequestration.

Lastly, Part I of the assessment collected information on the *wood drain*, in other words fellings, which are the sum of the volume of wood removed from the forest and unrecovered fellings. Data on commercial fellings are generally available and probably reasonably accurate, but more difficulties arise with other cuttings, which are often not recorded and consist to a large extent of fellings by owners and others for their own use. As for other parameters, the most reliable and complete data on fellings exist for exploitable forest. They are particularly useful for comparing drain with net increment and growing stock data, which allows assessments to be made of the harvesting ratio (fellings as a per cent of increment or of growing stock or per hectare).

PART II

The role of the forest in supplying environmental and other non-wood goods and services (non-wood benefits)

As mentioned earlier, the information collected in Part II of the assessment is much more of a qualitative nature than that in Part I. Nonetheless, an effort was made in designing the questionnaire to obtain as much quantitative information as possible, partly so as to allow comparative analysis. Part II consisted of the following sections:

- ❑ Importance of forest functions by area;
- ❑ Production of forest products other than wood;
- ❑ Policy and planning activities relating to forest functions;

- ☐ Areas of public concern and conflicts between forest functions.

For the first three sections, countries were asked to complete tables with official data or informed estimates and to complement this information with explanatory notes or with additional information which did not fit into the form of the enquiry.

The approach for the first question - *Importance of forest functions by area* - was to ask countries to classify the importance of each of the seven selected functions into three classes of importance: high, medium and low. They were provided with guidelines to follow in assigning the importance of the function. They had to allocate a proportion of the total area of the category of forest and other wooded land in question to each level of importance so that the total came to 100 per cent. For example, suppose that the total area was one million ha and the importance reported for a given function was 50 per cent high, 30 per cent medium and 20 per cent low, this meant that 500 000 ha were classed in the high importance category, 300 000 ha in the medium, and 200 000 in the low.

The functions selected for assessment in this way were:

- Wood production;
- Protection;
- Water;
- Grazing (range);
- Hunting;
- Nature conservation;
- Recreation.

Because the importance of functions can differ considerably according to the category and ownership of forest and other wooded land, countries were asked to provide importance classifications of the functions for four categories:

- Publicly owned forest;
- Privately owned forest;
- Publicly owned other wooded land;
- Privately owned other wooded land.

In practice, most countries provided replies for the first two categories, sometimes however not being able to distinguish between public and private forest.

A supplementary question asked for information about the number and area of *National Parks and nature reserves* and the proportion of forest and other wooded land in such areas.

For *forest products other than wood*, the importance of which has been becoming increasingly recognized, countries were asked to list all the products which have some importance to them, providing to the extent possible annual quantities and values of production.

Since supply and demand of most non-wood forest functions are not regulated by the market and consequently government at various levels intervenes to regulate them, the third question on *policy and planning activities relating to forest functions* was aimed at information that could be helpful in planning and policy making and their implementation. The approach was to ask whether there had been changes in the importance attached to the different functions since the previous (1980) assessment; if so, in which direction: more emphasis or less. Countries were also asked whether explicit plans existed to change the importance given to the different functions in the coming decade; and if so, whether it would be greater or less. These answers should be supported by background information explaining the reasons for change, the nature of the plans or policies, and the means for implementation.

The fourth question arose from the growing *public awareness and concern* about forests and forestry matters and the *conflicts between the different forest functions*. Countries were asked to identify and describe the main issues and conflicts, which could only be dealt with in a descriptive and qualitative way.

Evaluation of the methodologies

As pointed out at the beginning of this section, the methodologies involved in the collection of forest resource information in the developed countries are the ones employed by the countries themselves in their forest inventories. The collation of general forest resource information (Part I) at the international level is in essence by means of circulating a questionnaire. The national correspondents who fill in the questionnaire have an important role in working with the compilers (FAO/ECE secretariat) in checking, explaining and supplementing the basic information. While the questionnaire-plus-correspondents approach works well for Part I of the assessment, the correspondents have a more difficult and even more important role in Part II (the role of the forest in supplying environmental and other non-wood goods and services), because of the much more qualitative and subjective nature of the information.

The experience of the 1990 assessment of the developed countries has shown that the quality of the information was in general reasonable, but varied quite considerably from country to country. More could no doubt have been done to raise the overall quality, but this would have required substantial additional input, both by the countries and the secretariat. With plans already in hand for the year 2000 assessment, some suggestions on ways in which future assessments might be improved may be offered:

1) Strengthening the dialogue between forest inventory managers and the users of their information, at the national and international level, to ensure the "right" information is being collected (this is liable to change from one assessment to the next);
2) Further streamlining of the questionnaire used to collect data at the international level to restrict it to the most important elements from the users' point of view;
3) At the same time, ensuring that comparability is maintained as much as possible with previous assessments;
4) A special effort to obtain better information on land use changes;
5) Strengthening cooperation between the more experienced countries in the field of forest inventory and the secretariat, on the one hand, and those needing to develop their inventory capabilities, on the other, in order to bring the quality of data from the latter to a higher level. Some of the countries of central and eastern Europe with economies in transition fall into the latter category;
6) For Part II, a reappraisal at the international level of the approach and methodology for collecting information, as well as of the type of information needed;
7) Above all, recognition by governments and the responsible agencies of the importance of forest resource inventory activities is a prerequisite for effective follow-up in the field of forestry to UNCED and other high-level meetings, such as the Ministerial Conferences for the Protection of Forests in Europe, in order to provide reliable and comprehensive information on the forest resource needed for policy-making. Such information can only be made available if inventory and assessment activities are adequately funded and supported politically. With few exceptions, this is not the case at present at the national level; it is manifestly not so at the international level.

2

METHODOLOGY OF ASSESSMENT FOR THE DEVELOPING COUNTRIES

Preparatory Studies

Country data, available in the form of statistical tables or maps, have been the main source of information for the developing countries' part of the global forest resources assessment and the direct determinant of its quality and content. Therefore, a review of the current state of the country forest inventories is an appropriate starting point for discussion of the methodology of the Forest Resources Assessment Project. (see Table 17)

The findings on the current state of the country forest inventories can be summarized as follows:

- There is considerable variation among regions with respect to completeness and quality of the information, with Asia faring better than tropical America and the latter better than tropical Africa;
- There is considerable variation in the timeliness of the information. The data are about ten years old, on average. This is a potential source of bias in the assessment of change;
- There are some countries which have carried out more than one assessment. These countries, however, have not used appropriate techniques, such as Continuous Forest Inventory (CFI) design, for change assessment;
- Only a few countries have reliable estimates of actual plantations, although such estimates are essential for national forestry planning and policy-making;
- No country has carried out a national forest inventory containing information that can be used to generate reliable estimates of the total woody biomass and its change over time.

The above findings establish the fact that the existing forest resources information is not adequate to meet the needs of global assessment.

Review of approaches to assessment

The expert consultation held at Kotka, Finland in 1987 (Kotka I) recommended that, for developing countries, the 1990 assessment follow the approach of the FAO/UNEP 1980 assessment for estimating the forest cover area at end 1990 and then estimate the change by taking the difference between the 1990 and 1980 figures. The first results demonstrated clearly, however, that this approach is

Table 17
State of forest inventory in developing countries at end 1990

Region/ Continent	Number of countries under assessment	Number of countries with forest resources data at national level					
		Forest area information (number of assessments and reference years)				Additional information	
		No assessment	One assessment		More than one assessment	Forest plantations	Volume and biomass
			before 1981	1981-90			
TROPICAL							
Africa	45	3	28	12	2	42	2
Asia & Pacific	29	0	13	6	10	19	7
L. America & Caribbean	41	0	23	9	9	23	9
Total Tropical	**115**	**3**	**64**	**27**	**21**	**84**	**18**
NON-TROPICAL							
Africa	8	3	0	5	0	8	1
Asia & Pacific	17	1	10	2	4	17	5
L. America & Caribbean	3	0	1	2	0	3	0
Total non-tropical	**28**	**4**	**11**	**9**	**4**	**28**	**6**
ALL DEVELOPING							
Africa	53	6	28	17	2	50	3
Asia & Pacific	46	1	23	8	14	36	12
L. America & Caribbean	44	0	24	11	9	26	9
Total developing	**143**	**7**	**75**	**36**	**25**	**112**	**24**

Source: FORIS database

not suitable for the estimation of change over time, because the resulting estimates of change had high variance, being the sum of the variance of 1980 and 1990 estimates according to the law of propagation of errors.

Keeping the above limitations in view, investigations were initiated to find an approach which could produce acceptable results making the best use of available data, appropriate techniques and new technology (remote sensing, GIS, computerised database management and modelling techniques). The following were some of the tools and techniques investigated:

i) Use of a database management system for easy storage, retrieval, analysis and updating of information;
ii) Introduction of a modelling technique to estimate deforestation objectively;
iii) Use of auxiliary variables, dynamic in nature, such as population density and population growth, for which data are readily available and which are among the important driving forces behind deforestation;
iv) Reduction in size of the assessment unit from national to a subnational level, which is ecologically and demographically more homogeneous;
v) Use of variance-reducing techniques while making estimations, such as stratification of the subnational units by ecological criteria.

Methodology of the 1990 assessment

The assessment technique is presented in the form of a flow chart in figure 15. It consisted of the following three steps: (i) establishment of a computerized database; (ii) development of a deforestation model (or an adjustment function); and (iii) computation of results for the standard reference years.

Establishment of a database

The data compiled by the Project consisted of two categories:

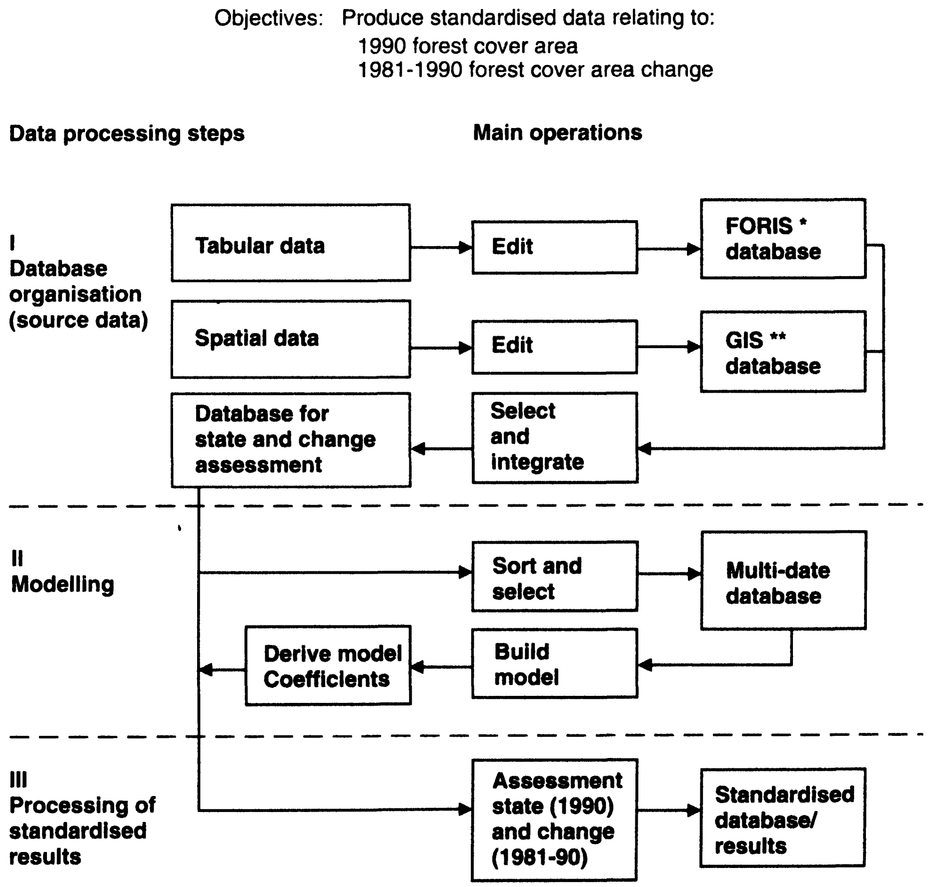
i) **Tabular data**, including forest resources, population and socio-economic data at the subnational level (province, state) on a consistent basis over the entire developing world;

ii) **Spatial data**, including ecofloristic zones, vegetation types and national and subnational boundaries.

A comprehensive Database Management System (DBMS) was developed in order to include statistical (FORIS) and spatial (GIS) variables used in the assessment process. Statistical variables mainly reported, and consequently stored in the data bank, at subnational unit level were integrated with cartography representing the units in a spatial way. Since both model variables and model results were stored in the DBMS, users can access the information through both statistical and spatial queries. Being the deforestation a location-specific process influenced by a number of spatial factors, various information layers were introduced in the

Figure 15

Forest cover state and change assessment (using existing reliable data)


Objectives: Produce standardised data relating to:
1990 forest cover area
1981-1990 forest cover area change
Data processing steps
Main operations
I
Database organisation (source data)
Tabular data
Edit
FORIS * database
Spatial data
Edit
GIS ** database
Database for state and change assessment
Select and integrate
II
Modelling
Sort and select
Multi-date database
Derive model Coefficients
Build model
III
Processing of standardised results
Assessment state (1990) and change (1981-90)
Standardised database/ results

* FORIS is the acronym for Forest Resources Information System. It is a computerised database to store/retrieve national/sub-national forest resource information

** GIS stands for Geographic Informaiton System used to store spatial/ cartographic and related statistical data

GIS for further studies. These layers include: protected areas, road and railroad networks, hydrology, topography, climatological data and satellite information such as vegetation maps derived from interpreted Landsat or NOAA imageries, Landsat World Reference System Grids.

More than 100 tropical and non-tropical (limited to Africa and South America) countries are included in the data bank. This body of information, which will be made available to the international community during 1995 in the form of CD-ROM, includes, in an integrated manner: a) demographic, vegetational and ecological data which were used during the forest resources assessment and b) baseline results for the reference years 1980 and 1990.

GIS and tabular databases represent an important outcome since they are at the same time output of the forest resources assessment activities and input for further studies. The deforestation process dynamics requires a continuous effort in keeping this information up-to-date, especially from the side of the mandatory international bodies (FAO and other UN agencies) in close cooperation with the recipient countries which play the major role of users and producers of the information.

Adjustment function

The forest cover data contained in FORIS referred to different periods and needed to be brought for reporting purposes to the standard years, namely 1980 and 1990. This was done with the help of an adjustment function (Syn. deforestation model) which correlates forest cover change in time with other variables including population density and population growth for the corresponding period, initial forest cover area and the ecological zone under consideration. For developing the function only multi-date data were used. The best fitting curve had the form of a logistic function.

The model has proved to be a valid and flexible tool with which to estimate deforestation at a global level and to relate forest cover changes with demographic and ecological variables. Given the scarcity of existing reliable multi-date observations, the model serves a very useful purpose in global forest resources assessment.

Estimation procedure

The FORIS database, in conjunction with the model, served: (i) to adjust forest cover data of the subnational units to the standard reference year 1990; and (ii) to produce estimates of the forest cover area change over the period 1981 to 1990. For these purposes the most recent forest inventory observation of a national/subnational unit is used as baseline, and forest cover area in 1980 and 1990 (standardized results) computed according to one of the following options:

i) Reliable multi-date inventories available: in this case the existing multi-date information is used to calibrate the general model with the local parameters and the resulting model is then used to compute the standardized results. This is the optimum case;
ii) Reliable single-date inventory available: in this case the standardized results are computed using the general model;
iii) No reliable inventory available: in this case estimates of baseline forest cover area are extracted from calibrated vegetation maps existing in the Project's GIS and are then used as input to the modelling procedure described for option (ii).

For each option, procedures were developed for integrating the FORIS and GIS data to compute the model parameters for each subnational unit and to provide forest cover areas 1980 and 1990 as standardized outputs.

The standard estimates for the forest cover state and change at subnational level are aggregated at national, regional and global levels. Keeping in view the law of propagation of errors, the global estimates are expected to be more precise than the subregional; and the subregional estimates more precise than the national and subnational ones.

In the present system of assessment the up-dating of results is an almost continuous process. Both the FORIS database and deforestation model parameters can be updated as and when additional country data become available. The addition of further records and fields in FORIS will improve the reliability of model parameters as well as precision of estimates for the country, which in turn will improve the precision of the estimates at regional and global levels.

State of forest biomass and assessment of change

Biomass of forests has become very relevant to studies related to global change. The biomass of forests provides estimates of the carbon pools in vegetation (about 50 per cent of biomass is carbon), and consequently the potential amount of carbon dioxide that can be added to the atmosphere when the forest is cleared and/or burned. Biomass is also a useful variable for comparing structural and functional attributes of forest ecosystems across a wide range of environmental conditions.

Not all tree biomass for domestic use originates from forests; significant quantities are obtained from non-forest lands such as woodlots, windbreaks and other line formations, home gardens, etc. It is recognised that these sources should be assessed in the future, but it was beyond the present scope of the assessment.

To estimate the biomass density of forests, use was made of existing volume over bark estimates (VOB) in the FORIS database which is converted to biomass density with the help of a biomass estimation function and further "expanding" this value to take into account the biomass of the other above ground components.

Research results based on actual inventory data across the tropics, show that for tropical broadleaved forests biomass expansion factors are significantly related to stemwood biomass (SB) according to the following model:

BEF = exp{3.213 - 0.506*ln(SB)}
for SB < 190 t/ha

= 1.74 for SB ^{3} 190 t/ha

The following function for estimating biomass from volume information was used

BD (t/ha) = VOB * WD * BEF

where:

BD = biomass density

VOB = volume over bark of all trees to 10 cm minimum diameter (m3/ha)

WD = average wood density (t/m3); values obtained from FRA 1990 guidelines

BEF = biomass expansion factor

No model is available at present for calculating biomass expansion factors for coniferous forests, because of a general lack of data for this type of analysis. Therefore the estimates presented in the Project guidelines were used.

This approach is of unknown reliability, because much of the VOB data were estimated generally through extrapolation from existing local and international forest inventories. However, this method has the advantage of being pan-tropic and can therefore be used with area estimates for 1990 to produce an assessment of the total biomass of tropical forests.

3

DEFINITIONS

General remarks

Within, the work of the forest resources assessment is currently being shared between the former FAO/ECE Agriculture and Timber Division, Geneva, which covers the developed countries; and the Forest Resources Division at FAO headquarters, Rome, which is responsible for the developing countries.

Terms and definitions for the Forest Resource Assessment 1990 — Developed countries

Forest Land: with tree crown cover (stand density) of more than about 20% of the area. Continuous forest with trees usually growing more than about 7m in height and able to produce wood. This includes both closed forest formulations where trees of various storeys and undergrowth cover a high proportion of the ground and open forest formulations with a continuous grass layer in which tree synusia cover at least 10% of the ground.

Other wooded land: Land which has some forestry characteristics but is not *forest* as defined above. It *includes*: open woodland and scrub, shrub and brushland (see below), whether or not used for pasture or range. It *excludes* land occupied by *"Trees outside the forest"* (see below).

Exploitable: Forest on which there are no legal, economic or technical restrictions on wood production. It includes areas where, although there are no such restrictions, harvesting is not currently taking place, for example, areas included in long-term utilization plans or intentions.

Unexploitable: Forest and other wooded land on which there are legal, economic or technical restrictions on wood production. It includes (a) forest and other wooded land with severe legal restrictions on wood production, e.g. national parks, nature reserves and other protected area such as those of special scientific, historical or cultural interest; (b) forest and other wooded land where physical productivity is too low or harvesting and transportation costs to the nearest market are too high to warrant wood harvesting, apart from occasional possible cuttings for auto-consumption.

Stocked (forest): Forest with existing tree crown cover (stand density) of more than about 20% of the area; also forest nurseries and seed orchards.

Unstocked (forest): Forest on which tree crown cover (stand density) has been reduced to less than 20% or has been removed as a result of human intervention or natural causes, e.g. by felling or burning, but which is expected to revert to stocked forest.

Scrub, shrub and brushland: Land with scrub, shrub or stunted trees where the main woody elements are shrubs (usually more than 50 cm and less than 7 m in height), covering more than about 20% of the area, not primarily used for agricultural or other non-forestry purposes, such as grazing of domestic animals. "Trees outside the forest" are excluded.

Under active management: Forest and other wooded land that is managed according to a professionally prepared plan or is otherwise under a recognized form of management applied regularly over a long period (five years or more).

Net change: The net difference over given period between increase in area of forest and other wooded land from afforestation and natural extension and loss of such land to other uses.

Growing stock: The living part of the standing volume.

Forest Resources Assessment 1990 of the developing countries

Forests are ecological systems with a minimum crown coverage of land surface (here assumed as 10 percent) and generally associated with wild flora, fauna and natural soil conditions; and not subject to agronomic practices. For the present assessments, a tree is defined as a woody perennial with a single main stem (except in coppice crops where multiple stems replace a single stem), a more or less definite crown and a minimum height of more than 5 meters on maturity. Only forest areas more than 100 ha (minimum area) are considered.

Forests are further subdivided according to their origin into two categories:

- i) Natural forests are a subset of forests composed of tree species known to be indigenous to the area.
- ii) Plantation forests refer to:
  - a) Forests established artificially by afforestation on lands which previously did not carry forest within living memory.
  - b) Forests established artificially by reforestation of land which carried forest before and involving the replacement of the indigenous species by a new and essentially different species or genetic variety.

Other wooded land includes the following two categories:

- i) Forest fallow refers to all complexes of woody vegetation deriving from the clearing of natural forest for shifting agriculture. It consists of a mosaic of various succession phases and includes patches of uncleared forests and agriculture fields which cannot be realistically segregated and accounted for area-wise, especially from satellite imagery. Forest fallow is an intermediate class between forest and nonforest land uses. Part of the area which is not under cultivation may have appearance of a secondary forest. Even the part currently under cultivation sometimes has appearance of forest, due to presence of tree cover. Accurate separation between forest and forest fallow may not always be possible.
- ii) Shrubs refer to vegetation types where the dominant woody elements are shrubs with more than 50 cm and less than 5 meters height on maturity. The height limits for trees and shrubs should be interpreted with flexibility, particularly where the minimum tree and maximum shrub heights, which may vary between 5 and 7 meters approximately.

Other Land Use account for the balance of the land area. Since total land will, to the degree possible, be reported by the main land use classes from the FAO Production Yearbook, agricultural and other land classes need to be accounted for, giving a total class set as follows:

- i) Arable land
- ii) Land under permanent crops
- iii) Permanent meadows and pastures
- iv) Forests and wooded lands
- v) Other land

The ecological regions are defined with the help of ecological parameters: climate, physiography, and soils. The climatic parameters include mean annual rainfall, rainfall regime, length of the dry season, relative humidity and temperature.

Ecofloristic zones are further sub-division of ecological regions based on the dominant or characteristic woody species of the flora, with attention given to their successional position and the leaf-retining characteristics of the forest canopy (i.e. phenology). For each ecofloristic zone it is possible to define the corresponding climax vegetation formation.

The classification of vegetation formations is based mainly on physiognomic criteria which can be seen in field and remote sensing documents, such as density, continuity of plant cover, height, etc. The denomination of the formations (e.g. dense forests, secondary forests, woodlands, thickets, savannas, etc.) is derived from the classification of Yangambi (1956) and of UNESCO (1973). The vegetation formations are further subdivided on the basis of density, ranging from the woody types that are the most closed, to the types that are the most open. This reflects the different stages of the regressive series or, in very rare cases, the evolutionary tendency of the vegetation within a zone. Dominant forest formations by ecological zone are distinguished as follows.

Volumes are defined using one of the following specifications:

VOB - Gross "Volume Over Bark" of free bole (from stump or buttresses to crown point or first main branch) of all living trees of all species more than 10 cm diameter at breast height (or above buttresses if these are higher). "Volume over bark" is generally used in the tropics as opposed to "Volume inside bark" because there are no volume tables that account for bark thickness.

Biomass is the oven dry weight of all species of trees to a minimum dbh of 10 cm, above ground only, and includes main stems, branches, twigs, leaves and fruits. Different procedures in estimating biomass will be followed for the different vegetation types.

Deforestation is defined in the strict sense of complete clearing of tree formations (closed or open) and their replacement by non-forest land uses (alienation).

Deforestation refers to "change of land use from forest to other land use or depletion of forest crown cover to less than 10 per cent". Changes within the forest class which negatively affect the stand or site and, in particular, lower the production capacity, are termed forest degradation. Thus degradation is not reflected in the estimates of deforestation. In the case of degradation of forests in developed countries, information on forest damage and threats to the forest ecosystems of the industrialized countries are collected regularly under other programmes of the Joint FAO/ECE Agriculture and Timber Division (e.g. forest fire statistics, monitoring of forest dieback).

Forest Degradation takes different forms, particularly in open formations, derived mainly from human activities such as over-grazing, over-exploitation (for fuelwood in particular), repeated fires, or due to attacks by insects, diseases, plant parasites or other natural sources such as cyclones. In most cases forest degradation does not show up so much as a decrease in the area of woody vegetation but rather as a gradual reduction of biomass, changes in species composition and soil degradation. The logging of forests for sawlogs and veneer logs without a proper management plan can contribute to forest degradation if the extraction of mature trees is not accompanied with their regeneration or if the use of heavy machinery causes soil compaction or loss of productive forest area.

Definitions used in relation to protected areas

All protected areas combine natural areas in five World Conservation Union, formerly the International Union for Conservation of Nature and Natural Resources (IUCN), management categories (areas at least 1 000 hectares).

Totally protected areas are maintained in a natural state and are closed to extractive uses. They encompass the following three management categories:

Category I. Scientific reserves and strict nature reserves possess outstanding, representative ecosystems. Public access is generally limited, with only scientific research and educational use permitted.

Category II. National parks and provincial parks are relatively large areas of national or international significance not materially altered by humans. Visitors may use them for recreation and study.

Category III. Natural monuments and natural landmarks contain unique geological formations, special animals or plants, or unusual habitats.

Partially protected areas are areas that may be managed for specific uses, such as recreation or tourism, or areas that provide optimum conditions for certain species or communities of wildlife.

Some extractive use within these areas is allowed. They encompass two management categories:

Category IV. Managed nature reserves and wildlife sanctuaries are protected for specific purposes, such as conservation of a significant plant or animal species.

Category V. Protected landscapes and sea-scapes may be entirely natural or may include cultural landscapes (e.g. scenically attractive agricultural areas).

Definitions used in relation to wood production

Fuelwood and charcoal

Wood in the rough (from trunks, and branches of trees) to be used as fuel for purposes such as cooking, heating or power production. Wood for charcoal, pit kilns and portable ovens is included. The figure for trade in charcoal are given in weight.

Industrial roundwood

The commodities included are sawlogs and veneer logs, pulpwood, other industrial roundwood and, in the case of trade, chips and particles and wood residues.

Definitions used in remote sensing survey

A brief definition of the land cover classes used in the pan-tropical survey of forest resources based on high resolution satellite data is presented in the box below.

Other specifications:

Scale: the scale of the interpreted satellite images is 1 : 250 000.

Minimum mapping unit = 3 x 3 mm, approximately 50 ha, or 2mm width for linear features.

A forest class is considered **continuous** or non fragmented when the non-forest elements (below minimum mapping unit) present in it are less than 30 % of the class.

A forest class is considered **fragmented** when the non-forest elements (below minimum mapping unit) present in it are more than 30 % of the class and the forest fraction is between 10 and 70 %.

The **composite classes** (Fragmented Forest, Long Fallow, Short Fallow) are used where individual elements are below minimum mapping unit (< 3 x 3 mm).

Land cover classes used in the pan-tropical survey

	Average height	Canopy coverage	Description
LAND COVER CLASSES			
Closed Forest	> 5 m	> 40 %	Continuous tree formation of natural origin
Open Forest	> 5 m	10- 40 %	Continuous tree formation of natural origin
Shrubs	1-5 m	> 10 %	Low woody vegetation of natural origin
Other Land Cover		< 10 %	Land with woody vegetation below 10 %
Plantation	> 1 m	(dense)	Forestry or agricultural plantation
Water			Sea, lakes, reservoirs, rivers
COMPOSITE CLASSES:			
Fragmented Forest	(forest) > 5m	(forest) > 10 %	Mosaic of forest and non-forest with forest fraction between 10 and 70% of total area (estimated average 33%)
Long Fallow			Mosaic of mature forest, secondary forest, various stages of natural regrowth and cultivated areas with cultivated areas covering between 5 and 30 % of total area
Short Fallow			Mosaic of young secondary forest, various stages of natural regrowth and cultivated areas with cultivated areas covering between 30 and 50 % of total area

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62

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